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The Moa Fauna (Aves: Dinornithiformes) of the Auckland and Coromandel Regions, New Zealand

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Abstract

We examined museum collections to compile a list of all known moa remains collected within the Auckland area and Coromandel Peninsula (North Island, New Zealand) from both natural and archaeological contexts. Moa remains have been found at 45 locations within our study-area, with many locations represented by just a few bones in a largely fragmentary state. The collections are dominated by bones of the leg, with skulls, pelves and complete skeletons under-represented. Calculation of the minimum numbers of individuals (MNIs) represented by the remains reveals at least 74 moa individuals from Auckland and 101 from Coromandel Peninsula. Moa bones from the Auckland region were mostly recovered from natural sites (80% of the MNIs), principally the Late Holocene swamp site at Clevedon. Moa bones from the Coromandel were mostly found within archaeological sites (at least 60% of MNIs) that are concentrated on the Coromandel Peninsula's east coast. Identification of the remains shows that all four North Island moa species were present in Auckland and Coromandel during the last few thousand years. The regions differ in species representation, with *Anomalopteryx didiformis* best represented in Auckland and least represented in Coromandel, while *Dinornis novaeseelandiae* was strongly represented in Coromandel and least abundant in Auckland. These differences could be attributed to the habitat preferences of the moa species, and the uneven representation of habitats across our sites, but in the Coromandel region selective Māori hunting strategies may also have influenced the result.

Keywords

palaeontology; archaeology; Māori middens; *Anomalopteryx*; *Pachyornis*; *Euryapteryx*; *Dinornis*; geographical distribution; relative abundance

INTRODUCTION

The Auckland and Coromandel regions of the North Island, New Zealand, have few natural (non-archaeological) sites at which moa bones have been found compared to many other parts of New Zealand. The only major natural deposit of moa bones is a swamp site near Clevedon, Auckland, which yielded hundreds of bone elements, representing multiple individuals (Gill 2003). There are few archaeological sites containing moa bones in the Auckland area, in comparison to the east coast of the Coromandel Peninsula which has numerous early Māori sites in association with moa remains (Davidson 1979). However, nearly all natural and archaeological moa sites have yielded few and fragmentary moa remains.

A moa species, not currently recognised, was described from the Auckland-Coromandel region. A femur from Opito Bay, Coromandel Peninsula, is the type specimen of *Anomalornis gracilis* Hutton, 1897 (previously named

Dinornis gracilis by R. Owen) and now attributed to *Anomalopteryx didiformis* (see details in Gill *et al.* 2010).

We undertook to compile all known records of moa bones from the Auckland and Coromandel regions, based on palaeontological and archaeological collections, to establish the distribution and relative abundances of the species present. Of special interest is whether moa bones found on near-shore and off-shore islands of the regions indicate natural populations or resulted from the transport of moa bones or carcasses from the mainland to Māori settlements.

Of the moa species recognised in current taxonomic listings (Gill *et al.* 2010; Worthy and Scofield 2012) only four are known from the North Island and are therefore contenders for the Auckland-Coromandel regions:

Family Emeidae

- (1) Little bush moa *Anomalopteryx didiformis* (North and South Islands)
- (2) Mappin's moa *Pachyornis geranoides* (North Island only)

(3) Coastal moa *Euryapteryx curtus curtus* (subspecies restricted to North Island).

Family Dinornithidae

(4) North Island giant moa *Dinornis novaezealandiae*.

The synonyms of these species—the disused names that may be present on older museum labels—are listed in Gill *et al.* (2010).

Identification of *Euryapteryx* has been problematic. Gill *et al.* (2010) recognised two species: *E. curtus* in the North Island (only) and the larger *E. gravis* in both islands. Worthy and Scofield (2012), based on evidence in Bunce *et al.* (2009), proposed a single species of *Euryapteryx* with two subspecies: *E. curtus curtus* in the North Island, *E. curtus gravis* in the South Island, and larger birds in both islands assumed to be females. Discovery of separate North Island and South Island species of *Dinornis* based on DNA evidence (Bunce *et al.* 2003; Huynen *et al.* 2003) overturned the previous notion that there were three species of *Dinornis* throughout the country. All North Island species except *A. didiformis* had marked sexual dimorphism, with females larger (Worthy and Scofield 2012).

During the Holocene, *A. didiformis* and *D. novaezealandiae* typically inhabited wet forests throughout much of the North Island and were rarer in dry coastal scrublands in Northland, Auckland, Coromandel, Hawkes Bay, Wairarapa and Manawatu (Worthy

1990; Worthy and Holdaway 2002). *E. curtus* and *P. geranoides* dominated (singly or together) the dry coastal scrublands, although they too could be found across the North Island.

METHODS

We defined our study-area, with habitat-based boundaries, as Region 9 (Auckland) and Region 10 (Coromandel) of the Department of Conservation's Ecological Regions (McEwen 1987; Fig. 1). These regions are at the same latitude, but separated by the Firth of Thames, and form roughly the section of the North Island lying between about 36°00'S and 37°30'S. To begin compiling a list of known sites within the study-area at which moa bones have been found (Appendices 1 and 2), we extracted details from an unpublished list of North Island natural and archaeological deposits with Quaternary avifaunal remains (Millener 1981). Millener gave identification numbers to each location, and many sites have Fossil Record File Numbers (from a fossil locality database maintained by G.N.S. Science, Wellington). Archaeological sites have site numbers (from the Archsite database maintained by the New Zealand Archaeological Association). We extended Millener's list by adding more recent finds, supported by museum specimens and literature searches.

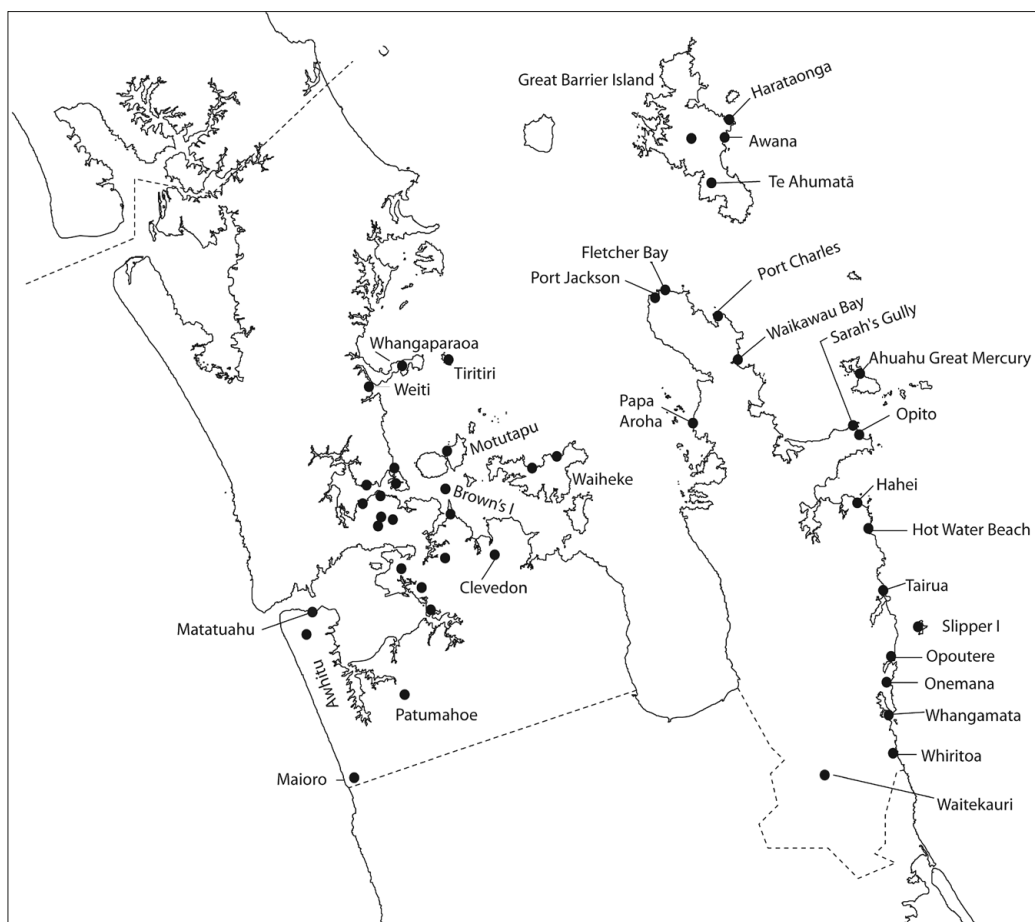


Figure 1. Auckland and Coromandel Ecological Regions showing places listed in the appendices.

Moa bones from most sites have been deposited in museum collections, with institutional codes as follows: AIM, specimen prefix LB (Auckland Museum land vertebrates collections); AIM, specimen prefix AR, AU or any other number without the LB format (Auckland Museum archaeology collections); AUG (Auckland University geology collections, Faculty of Science); AUA (Auckland University archaeology collections, School of Social Sciences); NMNZ (vertebrates collections, Museum of New Zealand Te Papa Tongarewa, Wellington); and CMC (vertebrates collections, Canterbury Museum, Christchurch). BJB examined the relevant bone material at AIM, AUG, AUA and NMNZ to confirm the bone elements, registration numbers and species identities. A list of relevant CMC holdings was obtained from the curator. Abbreviations used for the names of bone elements (singular or plural) are: fem = femur, tbt = tibiotarsus, tmt = tarsometatarsus. Side is indicated by L (left) and R (right). Fragments unable to be identified to species are common in archaeological collections and the number of fragments in each site is given to provide further information on relative abundance and distribution of moa bone. Undiagnostic fragments are predominantly in the archaeological collections at AIM unless otherwise stated. Identifications of some archaeological bone fragments from the Coromandel region have been determined using DNA (McCallum *et al.* 2013) and are included in Appendix 2.

Species identifications focused on the three principal leg bones since intact skulls and pelvis were rare from sites in our study regions. Worthy and Holdaway (2002: Appendix 2) provided an illustrated key to the identification of moa leg bones. This is the only modern identification tool, yet some of the important bone differences characterised in the key are typical rather than invariable. Thus, identification of moa bones from morphology can be difficult, even with whole bones. To compound identification problems, moa bones—especially those from archaeological sites—are often damaged, burnt, reworked or incomplete and lacking diagnostic features.

Bones of *Dinornis* are often recognisable by their large size and from some distinctive aspects of their shape. However, when considering fragments, conclusions on size alone are difficult because *D. novaezealandiae* and *E. curtus* had large females and smaller males. Therefore, the tibiotarsus of a large (female) North Island *Euryapteryx* may have a shaft as thick as that of a small (male) North Island *Dinornis*. Males of *E. curtus*, and both sexes of the two other North Island emeid species had smaller bones on average than those of *Dinornis*. The leg bones of the smaller North Island moas have a few distinguishing features (Worthy 2000; Worthy and Holdaway 2002) but if the diagnostic bone regions are missing or damaged, then species discrimination may be difficult. In our study we used the category ‘small moa (Emeidae)’ for bones from small species (i.e., not *Dinornis*) but for which no narrower identification was possible. Bones permitting no taxonomic identification narrower than ‘moa’ are listed as ‘moa (Dinornithiformes)’.

The moa species identifications given in this paper were determined by examination of the leg bones by BJB, or—as recorded on specimen labels, or in the literature—by R.J. Scarlett, P.R. Millener, T.H. Worthy or R.P. Scofield. A minimum number of individuals (MNI) was established for each species category at each site by identifying bone elements, determining their side (L or R), and considering individual size and immaturity (whether or not bones or fragments could have come from the same individual based on matching size and any signs of immaturity). For example, a collection comprising one L tmt and one R tmt would have MNI = 1 if the two bones matched in size, or MNI = 2 if they were a mismatch. Sites containing only undiagnostic fragmented remains were given MNIs of 1 to ensure they were represented in the counts for ‘small moa (Emeidae)’ and ‘moa (Dinornithiformes)’. MNIs were not assigned for eggshell fragments or presumed gastroliths.

We categorised the sites at which moa bones have been recorded as natural (i.e., palaeontological, with no indication of human associations), archaeological (Māori sites) or ‘dune/midden’ where bones from surface collecting might be natural or culturally associated. Moa bones in New Zealand coastal sand-dunes have two possible origins: (1) natural accumulation during the c. 5,500 years since current sea-levels were attained and the dunes began to be formed (e.g. Stevens 1985; Brook 1999a, b), or (2) accumulation in Māori kitchen middens following Polynesian settlement, from the early 1300s, and before moa extinction, which was possibly within 100–150 years of first human arrival (Holdaway and Jacomb 2000). Māori middens with moa bones also contain large numbers of artefacts such as fish hooks made from the bone. Very few intact moa bones have been recovered from archaeological contexts. The bone fragments tend to have patterns of breakage (especially greenstick fractures), cut or drill marks and scorching, suggesting they were from fresh bones. Potentially, repeated cycles of exposure and reburial in sand-dunes may jumble together bones from natural and archaeological contexts (Scarlett 1979). However, after consulting archaeological excavation reports we are confident that the majority of bones excavated from archaeological sites in this review are cultural in origin. Where this is not the case the bones are categorised as ‘dune/midden’ (Table 1), and in several instances bones that are clearly from below the cultural layers are identified as such.

RESULTS

Appendices 1 and 2 list the sites at which moa remains have been recorded in the Auckland and Coromandel Ecological Regions (respectively) and provide details of the remains (bones, gizzard stones/gastroliths and eggshell fragments). There are moa records from 24 Auckland geographic locations and 21 Coromandel locations. At most sites the moa remains are sparse and fragmentary, and our study confirms that the regions have not been conducive to the abundant and widespread preservation of moa remains. Estimated MNIs are given in the appendices for each site, or for separate

assemblages from within broader geographic locations. These MNIs are grouped in Table 1. In total the moa remains represent at least 74 individual birds in the Auckland region and 101 in Coromandel.

The main regional difference is that Auckland has yielded moa remains mostly from natural sites (60 individuals, 81%; Table 1), principally the swamp site at Clevedon (33 individuals) which accounts for more than half of those birds. The Coromandel region, by contrast, has a dominance of moa remains from archaeological sites (64 individuals, 64%; with additional remains—31 individuals, 31%—from ambiguous ‘dune/midden’ sites), and only 6 individuals, 6%, from natural deposits, reflecting the abundance and concentration of archaeological sites along the Coromandel east coast.

Of the total of 175 moa individuals from both regions, 112 individuals could be identified to species (64%; from Table 1) and 63 could not be identified because the remains were undiagnostic. The numbers show that during the last few thousand years all four North Island moa species were present in the Auckland-Coromandel regions although uneven in occurrence. *Euryapteryx curtus* was the most abundant moa across the two regions (36 individuals, 32% of the total identified to species). *Dinornis novaezealandiae* (29, 26%) and *Anomalopteryx didiformis* (28, 25%) were next in abundance, closely followed by *Pachyornis geranoides* (19, 17%).

However, the regional results differed markedly in species representation. In Auckland, for the 55 identified moas (from Table 1), the relative abundances were

A. didiformis 43%, *E. curtus* 31%, and *P. geranoides* and *D. novaezealandiae* 13% each. For the 57 identified Coromandel moas, the numbers were *D. novaezealandiae* 39%, *E. curtus* 33%, *P. geranoides* 21% and *A. didiformis* 7%. The commonest and rarest species in the two regions are reversed. This is shown in Fig. 2 which compares the two regions using the percentage frequency of MNIs for all the identification categories, not just identified species. There were too few identified moas in Auckland archaeological sites, or in Coromandel natural sites, to make sound intra-regional comparisons of species composition in natural vs archaeological sites. However, the scarcity of *A. didiformis* in Coromandel archaeological sites is notable: only Port Jackson and Opito Bay have firm identifications of *A. didiformis*, and in both cases from ambiguous dune/midden contexts (Appendix 2).

DISCUSSION

Our attempt to identify moa species from bone morphology was limited by the difficulty of this task generally, especially with isolated bones and those that are damaged and fragmented. There is further potential to examine the Auckland-Coromandel archaeological collections using DNA (e.g., McCallum *et al.* 2013) to confirm or expand the known species at each site, and understand better the hunting strategies of Māori and which species were more desirable as raw material for artefacts.

Besides difficulties with species identification, there are also limitations with assessing MNIs at sites

Table 1. Species composition of moa bones (as minimum numbers of individual birds) tallied across all known sites in the Auckland and Coromandel regions (Appendices 1 and 2). The species assignments use the current taxonomy (Gill *et al.* 2010; Worthy and Scofield 2012).

	Auckland				Coromandel			
	natural	archaeo-logical	dune/midden	TOTAL	natural	archaeo-logical	dune/midden	TOTAL
<i>Anomalopteryx didiformis</i>	24	0	0	24	0	0	4	4
<i>Pachyornis geranoides</i>	4	3	0	7	4	5	3	12
<i>Euryapteryx curtus</i>	17	0	0	17	0	19	0	19
unidentified small moa (Emeidae)	5	7	0	12	1	21	17	39
TOTAL Emeidae	50	10	0	60	5	45	24	74
<i>Dinornis novaezealandiae</i>	5	2	0	7	0	15	7	22
unidentified moa (Dinornithiformes)	5	2	0	7	1	4	0	5
TOTAL moa	60	14	0	74	6	64	31	101

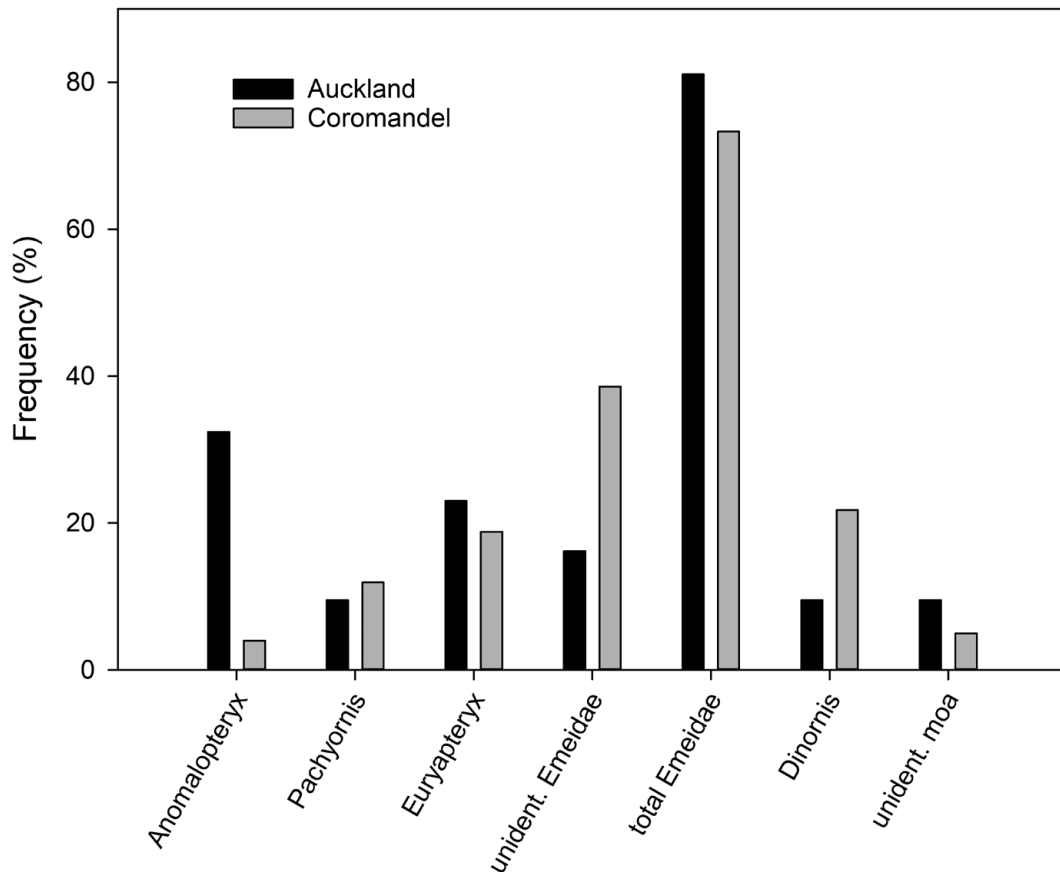


Figure 2. Histogram comparing the Auckland and Coromandel regions for the frequency (%) of the MNIs (minimum number of individuals) of the various taxonomic categories of moas as determined from bones in museum collections. The categories 'total Emeidae', 'Dinornis' and 'unidentified moa' add up to 100%.

to quantify and compare the relative abundance of moa species. If the same sites were sampled repeatedly at different times and the collections sent to different museums, we assessed these separately. This introduces a potential inflation of numbers as the same skeleton may have been re-sampled if it extended through multiple horizontal layers to be revealed by successive archaeological excavations or erosive periods followed by surface collection. However, this is countered by the conservative nature of MNIs which calculate only the minimum number of birds signified by a group of bones. Our numbers of moa individuals, and species identifications, are indicative rather than definitive.

The compilation of all known recorded moa remains from the Auckland and Coromandel regions confirms what we suspected at the outset—that moa bones are relatively scarce in the area, with usually only a few bones found at each site. In general there is a dearth of complete skeletons (Fig. 3), skulls (Fig. 4) and intact pelves. For archaeological sites, typically only leg bones (femur, tibiotarsus and tarsometatarsus), associated with a high yield of meat, and used to make artefacts (Figs 5–7), were carried back to living or hunting sites (Anderson 2003). Both regions have limited sand-dunes and swamplands, and no limestone caves, all of which have been major sources of preserved moa bones in other regions.

The only sizeable discovery of moa bones at a natural site within the study regions was at the Late Holocene swamp site near Clevedon, Auckland (Gill 2003), but even there the bones were mostly jumbled, rather than discrete skeletons, and few skulls and pelves are among the surviving specimens. Moa bone is a common feature of early Māori archaeological sites along the east coast of the Coromandel Peninsula, yielding numerous fragments, often displaying fracture patterning, drill holes or cut marks indicating its use as a resource in artefact manufacture. However, much greater numbers of moa bones have been recovered at other North Island archaeological sites, such as Houhora (Northland), Kaupokonui (Taranaki) and Foxton (Manawatu), and at many South Island localities (Anderson 2003).

A femur of *A. didiformis* from the Clevedon site was radiocarbon-dated (Millener 1981) with an estimated age of 1315 ± 70 years BP (NZ4871C). Large quantities of seeds of podocarps and other forest trees were found associated with the moa bones, indicating that the mire site had been surrounded by tall podocarp forest. All assessments of species composition at the site (Table 2) indicate a dominance of *A. didiformis* with lesser numbers of the three other North Island moas. This moa fauna is typical of North Island wet forest sites (Worthy 1990; Worthy and Holdaway 2002: 193), and Clevedon



Figure 3. Bones from a skeleton of *Pachyornis geranoides* collected from sand-dunes at Papa Aroha, Coromandel Peninsula, by S.C.L. McCall in 1926. The L femur at top left is 193 mm long. Auckland War Memorial Museum, LB6064.



Figure 4. Skull of *Anomalopteryx didiformis* collected at Eastern Beach, Bucklands Beach, Auckland, by E. Pegler in 1954. The bone is partly obscured by concretionary matrix. Smallest divisions on scale are 1 mm. Auckland War Memorial Museum, LB5806.

gives the best indication of the pre-human moa fauna of closed-forest sites in the Auckland-Coromandel region.

We noted differences in the relative abundance of moa species between Auckland and Coromandel, but the numbers were possibly biased by an unevenness of the habitats associated with the sites. In the Auckland region, moa bone sites were spread across a wide range of habitats including both tall forest (e.g., Clevedon) and scrubland (e.g., across the Auckland volcanic field). The Coromandel archaeological sites, in contrast, were all in, or close to, coastal sand-dunes and drier coastal margins more suited to *E. curtus*. The scarcity of *A. didiformis* in the Coromandel archaeological sites possibly reflects the species' natural preference for wet forest environments but absence from indisputably culturally associated deposits suggests that there may be other reasons. Māori were mobile, gathering food widely around a settlement site from many environments (Davidson 1979) and it is unlikely *A. didiformis* would be overlooked as food because it inhabited forest. *D. novaezealandiae* ranged widely through forest yet is present in most Coromandel sites. *A. didiformis* may yet be found in the undiagnostic fragments, but it is also possible that the species was scarce generally on the Coromandel at the time of Māori settlement.

In the Auckland region only four of the seven archaeological sites with moa have been excavated, and there is an expectation that a larger sample of bones would be recovered from these sites compared to surface finds. *A. didiformis* and *E. curtus* are not represented from the archaeological excavations as identifiable elements, but may be present in the undiagnostic fragments. However, with similar results to the distribution on



Figure 5. Near-intact *Euryapteryx curtus* L femur (left of picture), and R tarsometatarsus of small moa (Emeidae), from Port Jackson archaeological site. Auckland War Memorial Museum, 1995.47.6.

Table 2. Assessments of species composition of moa bones (as minimum numbers of individual birds) recovered from the swamp site near Clevedon, Auckland. The species assignments have been changed to the current taxonomy (Gill *et al.* 2010; Worthy and Scofield 2012). The first column is from an article in the *New Zealand Herald* of 25 September 1912 (p. 8), the year of discovery, after T.F. Cheeseman had visited the site and identified the bones. The remaining columns are based on specimens in the Auckland Museum collection, the *Euryapteryx* bones being missing in 2002.

	N.Z. Herald 1912	Millener 1981	Gill 2003
year of assessment	1912	1978	2002
<i>Anomalopteryx didiformis</i>	26	20	16
<i>Pachyornis geranoides</i>	0	2	2
<i>Euryapteryx curtus</i>	6	10	0
<i>Dinornis novaezealandiae</i>	1	1	1
species uncertain	1	0	1
TOTAL	34	33	20

the Coromandel Peninsula *A. didiformis* may also not have been common on the Tāmaki isthmus, and the abundance of *E. curtus* may have been distorted by the Clevedon Swamp individuals. *D. novaezealandiae* is also poorly represented in contrast to archaeological sites on the Coromandel Peninsula, and present only in the Matatua site on Awhitu Peninsula and at Owhiti Bay on Waiheke. Both are most like the Coromandel sites and have extensive evidence of fish hook manufacture and waste moa bone pieces. Overall, chronologically early sites which potentially could have contained moa are not well represented in the Auckland region, and in particular the Tāmaki isthmus, for reasons including reclamation and historic development of foreshore areas where the sites are more likely to be situated.

At the start of the Holocene Epoch, around 10,000 years ago, sea-levels were much lower than at present and all the islands in our study regions (including Great and Little Barrier Islands) were connected by land to

the current mainland (Stevens 1985). It is likely that all or most of the larger islands (including Waiheke Island) supported remnant moa populations at the time of Polynesian settlement. Smaller islands may have presented more challenging landscapes for moa survival after sea-level rise, with vegetation patterns dominated by monocotyledons and tree-ferns (Prebble *et al.* 2019), making moa populations vulnerable well before Polynesian settlement. Moa remains found on small islands (Tiritiri Matangi, Motutapu, Motukorea Brown's, Ahuahu Great Mercury and Slipper) are all from archaeological sites. On Ahuahu Great Mercury Island the tracheal rings, vertebrae, phalanges and fragments of leg bones from the Te Matakū Coralie Bay site, likely represent birds brought from the mainland. The low incidence of bone fragments and moa bone fish hooks in this site, when compared to similarly-aged sites on the Coromandel mainland, suggests moas were not readily available on the island.



Figure 6. Proximal end of *Dinornis novaezealandiae* L tarsometatarsus (top left) and moa bone fragments typical of archaeological sites, Opito Beach Midden. Auckland War Memorial Museum, 2014.80.783.



Figure 7. Awl fashioned from a thick bone fragment assumed to be from *Dinornis novaezealandiae*; Te Matakau archaeological site, Ahuahu Great Mercury Island. Auckland War Memorial Museum, 48928.

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APPENDIX 1. Moa Records from Auckland Ecological Region

Region comprises eight Ecological Districts but there are no recorded moa remains from 09.02 (Waitakere Ecological District) and 09.04 (Rangitoto Ecological District).

09.01 Rodney Ecological District

Weiti Heads, Silverdale

Millener's site 73; swamp.

P. geranoides. AIM LB6022 (181/28, Moa 110, MOA8.9), pres. by G. Graham 1928; L tmt. MNI = 1.

Whangaparaoa Peninsula

Millener's site 74; swamp. AIM LB6768 (9/58, Moa 465, MOA4.35), coll. by Mr Goymour 1958.

A. didiformis. L fem. MNI = 1.

Moa (Dinornithiformes). R tbt (immature?). MNI = 1.

09.03 Tamaki Ecological District

Takapuna Beach, North Auckland

Geological context uncertain.

Small moa (Emeidae). AUG 14934–5, coll. by B. Hayes; shafts of 2 R tbt. MNI = 2.

Moa (Dinornithiformes). AUG 15050, coll. by B. Hayes Dec. 1996; shaft of ?fem. MNI = 1.

Kendall Bay, Birkenhead, North Auckland

Swamp or sand-dune.

Small moa (Emeidae). AIM LB14135, coll. by D.L. Robinson 2010, found on beach at high-tide level; R tmt. MNI = 1.

Torpedo Bay, Devonport, North Auckland

(a) Fossil Record File No. R11/f195; geological context uncertain.

Small moa (Emeidae). AUG 15007, coll. by B. Hayes Feb. 1996; shaft of femur. MNI = 1.

(b) Site of Torpedo Bay Navy Museum. Archaeological site R11/1945; midden (Campbell *et al.* 2018). Unregistered (not yet in an institutional collection);

excavated 2009.

P. geranoides. L fem. MNI = 1.

Small moa (Emeidae). L fem, fragments of L&R tbt, phalanges. MNI = 1.

(c) Site of Masonic Tavern. Archaeological site R11/2517; natural sand-dune site underlying early Māori and historical deposits, but moa bones seem to be from Māori cultural layer; excavated 2010 and 2013 (Geometria 2014).

P. geranoides. Unregistered (not yet in an institutional collection); R fem, proximal end of L tbt, proximal end of fibula, vertebra, phalanx. MNI = 1.

Customs Street, Auckland City

Millener's site 84; Fossil Record File No. N42/f670; Holocene marine mud (Nelson and Grant-Mackie 1980).

A. didiformis. AIM MOA1.118 (157/70), coll.

by K. Goss 1969 during construction of hotel foundations, corner of Queen and Customs Streets; R fem (see Fig. 2 of Nelson and Grant-Mackie 1980). MNI = 1. The bone yielded a radiocarbon age of c. 7520 years B.P. (Nelson and Grant-Mackie 1980). No registration number was given by Nelson and Grant-Mackie (1980), but this bone is registered in the AIM land vertebrates collection (MOA1.118), as noted by Millener (1981); currently missing, possibly destroyed by the dating procedure.

Westmere, Auckland

Millener's site 87; swamp.

P. geranoides. AIM LB5978 (Moa 185, MOA9.4), coll. by L. Castle 1939; pelvis, L fem, L&R tbt. MNI = 1.

Royal Oak, Auckland

Tramways workshop. Millener's site 89; volcanic tuff.

Moa (Dinornithiformes). Bone found during site construction (Bartrum 1924); missing (not located in any institution by Millener or subsequently). MNI = 1.

One Tree Hill, Auckland

Millener's site 90; lava cave.

E. curtus. AUG 7883, coll. during construction of National Women's Hospital; missing, bones not located in collection Jan. 2019. MNI = 1.

Mt Wellington, Auckland

Millener's site 92; lava cave.

A. didiformis. AIM LB6245 (Moa 483, MOA17.7), coll. by M. Woods c. 1974; broken bones incl. R fem, L&R tbt. MNI = 1.

Ellerslie, Auckland

Millener's site 93; lava cave.

Moa (Dinornithiformes). Thomas Cheeseman explored a small cave near the Ellerslie race-course, obtaining a 'considerable number' of moa bones, 'but in such a bad state of preservation as to be useless for scientific purposes' (Cheeseman 1876). MNI = 1.

Bucklands Beach, Auckland

Eastern Beach. Millener's site 95; concretionary matrix in marine sand.

A. didiformis. AIM LB5806, coll. by E. Pegler of King's College Bird Club 1954; cranium (Fig. 4). MNI = 1. Found a little above high-tide level in a bayhead fill (R.B. Sibson, pers. comm. to BJG 1993). Largely intact but partly eroded and partly encased in hard sediment. The premaxillary is absent but both quadrates are in place; on the left side the jugal bar is present along with the proximal two-thirds of the mandible. The cranium is 66 mm wide between the postorbital processes. Species identification by Millener (1981).

Māngere, South Auckland

Māngere Speedway. Millener's site 91; geological context uncertain.

D. novaezealandiae. AIM LB7075 (Moa 230, MOA3.4), pres. by G. Henning before 1964, probably 1926–31; R tmt. MNI = 1.

Moa (Dinornithiformes). AIM LB1920, coll. by G. Henning c. 1930s; presumed gastroliths (3).

Wiri, South Auckland

"Rumney's Cave", Wiri Mountain; lava cave.

Moa (Dinornithiformes). LB15235, coll. by P. Crossley 2010; shafts of R fem and R tbt. MNI = 1. Found in cave (c. 10 m in from entrance) beside Rumney (Jacaranda) Cottage, Wiri Station Road.

East Tamaki, South Auckland

Whale's Quarry, Greenmount. Millener's site 98; scoria quarry.

E. curtus. AIM LB6246 (MOA1.162), coll. by J. Davidson 1978; broken bones incl. 3L fem, 4L&2R tbt, L tmt, skull fragments. MNI = 4. (Some of these bones are large, raising the possibility they are from a Pleistocene deposit, when individuals were larger on average than during the Holocene.)

09.05 Inner Gulf Islands Ecological District**Tiritiri Matangi Island**

Archaeological site R10/279; midden.

Unregistered (not yet in an institutional collection); excavated by R. Brassey 1997.

Small moa (Emeidae). Undiagnostic fragment (Rimmer 2004: 22). MNI = 1.

Motutapu Island

Sunde Site. Archaeological site R11/25 (N38/24);

Millener's site 76; midden (Scott 1970).

P. geranoides. AIM 2018.x.88.116; R fem. AIM AU1561.7; L tmt. MNI = 1.

Small moa (Emeidae). AIM 2018.x.88.123; phalanx.

AIM 2018.x.88.45, -63, -117; vertebrae, ribs, etc.

AIM 2018.x.88.48; tracheal ring. AIM 2018.x.88.125; undiagnostic fragment (1).

Moa (Dinornithiformes). CMC Av15925; partial phalanx.

Waiheke Island

(a) Owhiti Bay. Archaeological site S10/14; Millener's site 78; midden & possibly sand-dune.

Small moa (Emeidae). AIM AR7824; distal end of R tbt. AIM AR7825; distal end of L tbt. AIM AR8234; proximal end of R tmt. MNI = 1.

D. novaezealandiae. AIM AR7764; distal end of R tbt. MNI = 1.

Moa (Dinornithiformes). *E. curtus* (large, female) or *D. novaezealandiae*. AIM AR8234; distal end of R tbt. MNI = 1. AIM Archaeology collection; undiagnostic fragments (86).

(Plus, undiagnostic moa bones coll. by P.R. Millener 1978. Missing; bones not located in AUG collection Jan. 2019.)

(b) Onetangi Beach. Probably from sand-dune.

Small moa (Emeidae). Retained by finder, coll. by C. Anderson 2011, washed up on beach after storm; R tmt, water-worn, c. 170 mm total length. MNI = 1.

Motukorea Brown's Island

Archaeological site R11/565; midden.

Moa (Dinornithiformes). AIM 2019.77.8, AR7475.5; undiagnostic fragments (9). MNI = 1.

09.06 Awhitu Ecological District**Awhitu Peninsula**

(a) Matatuahu, Manukau South Head. Archaeological site Q11/344 (N46/16); midden.

Small moa (Emeidae). AIM AU402; distal end of R tbt. MNI = 1. CMC Av33204; burnt bone fragments; 3 large, 3 small. MNI = 3.

D. novaezealandiae. AIM AR7272; shaft of R tbt. MNI = 1.

Moa (Dinornithiformes). AIM archaeology site collection; undiagnostic fragments (18).

(b) Awhitu. Millener's site 101; sand-dune.

D. novaezealandiae. AIM LB7080 (Moa 327, MOA3.11), coll. 1922; shaft of R tbt. MNI = 1.

(c) Awhitu Swamp. Millener's site 103; swamp. *D. novaezealandiae*. AIM LB7071 (Moa 223, MOA3.2); R tbt, R tmt. AIM LB7077 (Moa 246, MOA3.7); L tbt, L tmt. Coll. by A. Mactier 1877. Bones stained very dark brown and broken or worn. The find was originally reported as "a pair of tibiae and metatarsi, together with a few phalanges" (Mactier 1878; see also Hutton 1892: 112). The four bones, now registered in two lots, are probably from the same bird. MNI = 1.

Maoro

Millener's site 107; sand-dune.

E. curtus. AIM unreg., coll. by E.G. Turbott 1940; missing, not found in collection by Millener or subsequently. MNI = 1.

D. novaezealandiae. AIM LB7102 (Moa 405, MOA3.15), coll. by E.G. Turbott 1940; partial bones: L&R tbt, L&R tmt, fragment of fem. MNI = 1.

09.07 Manukau Ecological District

Patumahoe

Millener's site 104; swamp.

E. curtus. AIM LB5996 (Moa 30, MOA8.2), coll. by W.E. Jones before 1969; L tmt.

MNI = 1. Millener (1981) recorded the site as 'Swamp'. There are no sand-dunes at this site, yet the bone is pale and sandy suggesting a dune origin and an erroneous location.

Homai, Manurewa

Geological context uncertain.

Moa (*Dinornithiformes*). AIM LB1917 (99/34), pres. by A.K. Duthie 1934. Presumed gastroliths (6).

09.08 Hunua Ecological District

Clevedon

Millener's site 99; assigned archaeological site number R11/832 (N42/875) though not an archaeological site; swamp (Gill 2003).

This site was located at the foot of hills north or west of Clevedon. An archaeologist located what he believed to be this site in 1979 and gave a precise sketch-map in the NZAA site description form (Plowman and Eaves 2010). The bones were discovered by a farmer (T.L. Smith) while draining swampy land in 1912 and collected by local naturalist H.S. Munro. Thomas Cheeseman of Auckland Museum identified the bones in 1912 as comprising 34 individuals (Table 2). Oliver (1949: 14) reported that the site yielded about 900 bones, representing 40–50 birds, and, indeed, an old photograph of the collection arranged outside a house (Gill 2003, Fig. 1) shows large piles of bones. The collection came to Auckland Museum from the Munro family, probably around 1954. The bones were reassessed by Phil Millener in 1978 as comprising 33 individuals (Table 2). Currently, some 280 bones from the Clevedon site, representing at least 20 birds, are present in the AIM collection (Gill 2003, Table 2). This reduced number suggests that only a residue of the original collection was received from the Munro family. The absence of *Euryapteryx* in the current Clevedon collection suggests that another group of bones was lost between 1978 and 2002. A left femur from AIM LB7122 (eight bones of one individual), which had been attributed to *P. geranoides*, was confirmed as this species by DNA analysis (Huynen *et al.* 2010; Table S2).

Species numbers are taken from Millener's assessment (1981; Table 2):

A. didiformis. MNI = 20.

P. geranoides. MNI = 2.

E. curtus. MNI = 10.

D. novaezealandiae. MNI = 1.

APPENDIX 2. Moa Records from Coromandel Ecological Region

Region comprises seven Ecological Districts but there are no recorded moa remains from 10.01 (Little Barrier Ecological District), 10.05 (Thames Ecological District), 10.08 (Te Aroha Ecological District) and 10.09 Mayor Ecological District.

10.02 Great Barrier Ecological District

Te Ahumatā (Whitecliffs), Great Barrier Island

Geological context uncertain.

Moa (*Dinornithiformes*). AIM LB1885, coll. 1963; presumed gastroliths (8).

Central Great Barrier Island

Geological context uncertain.

Moa (*Dinornithiformes*). AIM LB1951, coll. before 1965; presumed gastroliths (>20).

Harataonga Bay, Great Barrier Island

Archaeological site T08/5 (N30/5); Millener's site 66; midden (Allen and Holdaway 2010; Law 1972).

E. curtus. NMNZ S34025, surface coll. by T.H. Worthy 1983, possibly from a natural source; fragments of vertebrae & ribs, 11 phalanges, quadrate. MNI = 1.

D. novaezealandiae. AUA unregistered, coll. by G. Law 1972; missing, bones not located in collection Dec. 2019. MNI = 1.

Moa (*Dinornithiformes*). AUA unregistered, collected by M. Allen 2000; undiagnostic fragment (1).

Awana River, Great Barrier Island

Millener's site 69; midden.

E. curtus. AIM LB6665 (Moa 147, MOA16.17), coll. by S. Weetman 1886; R fem, R tbt (immature). MNI = 1.

10.03 Colville Ecological District

Port Jackson

Midden & possibly sand-dune.

(a) AIM Archaeology collection; archaeological site S09/53 (N35/88, Foster 1983).

E. curtus. AIM 1995.47.6; L fem (Fig. 5). MNI = 1.

Small moa (Emeidae). AIM 1995.47.4; distal end of R fem, distal end of L tbt. AIM 1995.47.3; shaft of fem, distal ends of 5L&1R tbt, phalanges, immature femoral shaft. AIM 1995.47.6; shaft of L fem, 1 proximal and 1 distal ends of R fem, proximal ends of 2L&1R tbt, whole R tmt (Fig. 5), proximal end of fibula. AIM 1995.47.2; proximal end of fem. AIM 1995.47.1; phalanges, fragment of distal end of L fem, proximal ends of 5 fibulae. AIM 2020.x.10; shaft of fem.

Eggshell fragments (>80, thin). MNI = 7.

D. novaezealandiae. AIM 1995.47.6; distal end of L tbt. MNI = 1.

Moa (Dinornithiformes). AIM 1995.47.2; 2 proximal ends of fibulae. AIM 1995.47.6; vertebrae, phalanges and ribs. AIM archaeology collection; undiagnostic fragments (1246).

(b) AUG collection; Fossil Record File No. S09/f001; Millener's site 71; coll. 1978 and 1981 by Gregory, Millener, Markham and Foley. Probably from S09/53.

A. didiformis. AUG 6109; two distal ends of L fem. MNI = 2.

P. geranoides. AUG 6107; proximal ends of L&R fem. AUG 7861; R fem. MNI = 2.

Small moa (Emeidae). AUG 6104; R fem. AUG 6105; proximal & distal ends of R fem, 4 proximal ends of tbt (sides not determined), distal ends of L&R tbt. AUG 6106; distal end of R fem, proximal end & 3 distal ends of L fem, proximal end of tbt (side not determined), 4 distal ends of L tbt. AUG 6107; proximal end of L fem, 4 proximal ends & 2 distal ends of R tbt, 2 distal ends of L tbt. AUG 6109; proximal & distal ends of L fem, proximal end & 2 distal ends of R tbt, proximal end & 2 distal ends of L tbt. AUG 6112; distal end of R fem, 2 distal ends of L fem, proximal & distal ends of L tbt. AUG 6115; L fem, L fem (immature), distal end of R tbt, proximal end of L tbt. AUG 7861; proximal & distal ends of R fem, 2 proximal ends & 2 distal ends of L tbt. MNI = 12.

D. novaezealandiae. AUG 6105; distal fragments of L&R fem, proximal end of R tbt, distal ends of L&R tbt. AUG 6115; proximal half of R fem, distal end of R tbt. MNI = 2.

(c) AIM Land Vertebrates collection. Probably from S09/53, but exact location of finds in relation to that site uncertain.

Small moa (Emeidae). LB14506, coll. by J.D. Osborne c. 1975; fragments (7) of L fem, 2L&1R tbt, fibulae. MNI = 2. LB14503, coll. by J.D. Osborne c. 1975; eggshell fragments (>1000, mostly thin). LB11741, coll. by B.J. Gill 2003; eggshell fragments (6, thin).

D. novaezealandiae. Coll. by J.D. Osborne c. 1975. LB14504; proximal end of L tbt. LB14505; proximal ends of L&R tbt. MNI = 2.

Fletcher Bay

From a clay bank.

Moa (Dinornithiformes). AIM LB14508, coll. by J.D. Osborne 1975; phalanx. MNI = 1.

Peninsula east of Port Charles

Geological context uncertain.

Moa (Dinornithiformes). AIM LB10376, coll. by D.J. Friend ca. 1970; presumed gastroliths (>100).

Waikawau Bay

Millener's site 72; sand-dune (Archey 1941: 93).

P. geranoides. AIM LB7110 (494/31), coll. by L.M. Cranwell 1929 from "Matamataharakeke", inland from Waikawau Bay; L&R mandibles. MNI = 1.

AIM LB6018 (Moa 49, MOA8.5), coll. by G. Archey 1932; almost complete skeleton (L tmt lacking) but condition poor, immature. MNI = 1.

Small moa (Emeidae). Record cited by Archey (1941: 44) as "*P. oweni*"; missing; bone not located by Millener. AUG, 4074.1, coll. by F. Moore 1971; eggshell fragments (c. 60; thin, worn). AIM LB11740, coll. by B.J. Gill 2003; eggshell fragments (5; thin, badly worn).

Papa Aroha

Millener's site 79; sand-dune.

P. geranoides. AIM LB6064 (Moa 395, MOA8.21), coll. by S.C.L. McCall 1926; almost complete skeleton (Fig. 2; skull also illustrated in Archey 1927: Figs. 1–4). MNI = 1. Site originally recorded as "sandhills at Amodeo Bay, Coromandel" (Archey 1927) but Millener (1981) thought it more likely to be the neighbouring bay (Papa Aroha). The McCall homestead was at Amodeo Bay (Clint Easton, pers. comm. to B.J.G.) and Archey may have assumed that to be the collecting locality.

Opito Bay

(a) Pōhutukawa Flaking Floor (Parker's Midden). Archaeological site T10/160 (N40/2); Millener's site 83; midden (Davidson 1979; Jolly and Murdoch 1973).

AIM Archaeology site collection:

E. curtus. AIM 2013.x.30; parts of 2 L fem, 3L&1R tbt, 2 phalanges, cranium. AIM 2013.x.36; distal end of chick tmt. AIM AU1513; head of fem. MNI = 4.

Moa (Dinornithiformes). AIM archaeology collection; undiagnostic fragments (38).

CMC Vertebrates collection, coll. 1959, 1960:

P. geranoides. Av16664; distal part L fem. Av16667; proximal part L fem. MNI = 1.

E. curtus. Av16285; part skeleton. Av16672; proximal part L fem. Av16673; part L fem, part L fibula.

Av16675; shaft of L tbt (immature). Av16915; L fem. MNI = 3.

Small moa (Emeidae). Av16665; distal part L fem. Av16666; proximal part L fem. Av16668; proximal fragment R fem. Av16669; parts L tbt. Av16670; proximal part R tbt. Av16671; proximal part L tbt. Av16676; proximal part R fem. Av16678; fragments of pelvis, vertebrae, ribs, leg bones etc. MNI = 2.

D. novaezealandiae. Av16674; 8 fragments of tbt, phalanx. MNI = 1.

(b) Opito Beach Midden. Archaeological site T10/161 (N40/3); Millener's site 80; midden (Boileau 1980). *E. curtus*. AIM 2014.80.781; distal end of L tbt. AIM 2014.80.780; part of distal end of tmt. MNI = 1. *D. novaezealandiae*. AIM 2014.80.782; part of distal end of R tbt. AIM 2014.80.783 (Fig. 6); proximal end of L tmt. MNI = 1. *Moa (Dinornithiformes)*. AIM archaeology collection; undiagnostic fragments (910).

(c) Arthur Black Midden. Archaeological site T10/164 (N40/6); midden (Green 1963). *E. curtus*. 2014.81.1; part of femur (shaft) identified by DNA analysis (McCallum et. al. 2013). MNI = 1. *Small moa (Emeidae)*. AIM 2014.81.1; parts of L&R tbt, L tmt, vertebra. *D. novaezealandiae*. 2014.81.1; fragment identified by DNA analysis (McCallum et. al. 2013). MNI = 1. *Moa (Dinornithiformes)*. AIM archaeological collection; undiagnostic fragments (5).

(d) Millener's site 82; location of finds in relation to above sites uncertain; probably mixed midden & sand-dune. *A. didiformis*. Natural History Museum (London) 32269; femur; record cited by Lydekker (1891), Hutton (1897), Millener (1981: 799). MNI = 1. AIM LB5644 (Moa 262, MOA1.83), coll. by L.W. Delph 1932; L&R fem, L&R tbt, L tmt. MNI = 1. *Small moa (Emeidae)*. AIM LB6694 (Moa 215, MOA16.30), coll. by L.W. Delph 1932, all in poor condition; 1L&2R fem (1 pair), L&R tbt (not a pair), L&R tmt (not a pair). MNI = 2. *D. novaezealandiae* (cited by Owen 1879, Hutton 1892). Missing, bones not found by Millener. MNI = 1.

Sarah's Gully, Opito

(a) Sarah's Gully Settlement. Archaeological site T10/167 (N40/9); Millener's site 81; midden (Davidson 2018, Table 10, identifications by T.H. Worthy). *P. geranoides*. AIM 2014.82.236; R tbt, likely to be natural deposit. AIM 2014.82.239; R tbt shaft fragment, natural deposit under midden. MNI = 2. *E. curtus*. CMC Av16663; distal part of R tbt. MNI = 1. *D. novaezealandiae*. AIM 2014.82.237; distal end of R tbt. MNI = 1. *Moa (Dinornithiformes)*. AIM 2014.82.238, AIM 2014.82.240–1; undiagnostic fragments (189).

(b) Sarah's Midden (Sarah's Flat). Archaeological site T10/171 (N40/13); midden (Davidson 2018, identifications by T.H. Worthy). *Small moa (Emeidae)*. AIM 2014.84.87; 2 phalanges. MNI = 1. *D. novaezealandiae*. AIM 2014.84.86; proximal end of L fibula. AIM 2014.84.85; distal end of L tbt, phalanx. MNI = 1 (Davidson 2018, Table 13). *Moa (Dinornithiformes)*. AIM 2014.84.87; tbt shaft fragment, fem shaft fragment. AIM 2014.84.88; undiagnostic fragments (35).

(c) Cross Creek. Archaeological site T10/399 (N40/260); midden & sand-dune (Sewell 1984). *D. novaezealandiae*. AIM AR7469.58; 3 vertebrae, 2 phalanges, quadrate, rib fragments, tracheal rings. MNI = 1. Probably from natural sand-dune deposit. *Moa (Dinornithiformes)*. AIM archaeology collection; undiagnostic fragments (52).

10.04 Mercury Islands Ecological District *Ahuahu Great Mercury Island*

Te Matakau site, Coralie Bay. Archaeological site T10/358 (N40/219); midden. *E. curtus*. AUA 118502; R tmt. MNI = 1. *Small moa (Emeidae)*. AUA 168052; distal end of R tbt. AUA 168053; R tmt. AIM 48835 distal end of L tbt. AIM 48939.1; proximal end of R tbt. AIM 48939.2; distal end of R tbt. Vertebrae, phalanges, tracheal rings (AUA and AIM). MNI = 2. *D. novaezealandiae*. AIM 48928; bone awl made from thick heavy bone (Fig. 7). MNI = 1. *Moa (Dinornithiformes)*. AIM 48912.7; eggshell fragments (264); surface-collected 1970s; thickness analysis (Gill in prep.) indicates at least 2 eggs, 1 small, 1 larger. AIM archaeology collection; undiagnostic fragments (7).

10.06 Tairua Ecological District *Hahei*

Archaeological site T11/326 (N44/97); Millener's site 86; midden (Edson and Brown 1977). *D. novaezealandiae*. AIM AR6058; section of shaft of large tbt(?). AIM archaeology collection; undiagnostic shaft fragments (6). MNI = 1. *Moa (Dinornithiformes)*. AIM AR6058; eggshell fragments (>50; most thin, a few thick), at least 2 eggs, 1 small, 1 larger.

Hot Water Beach

(a) Archaeological site T11/115 (N44/69); midden (Leahy 1974). *E. curtus*. AIM AR2590.1; part of R fem. AR2595.11; part of R fem. AR3292; fragment identified by DNA analysis (McCallum et. al. 2013). MNI = 2. *Small moa (Emeidae)*. AIM AR2508.12; part of phalanx. AIM AR2530.1; thoracic vertebra. AIM AR2530.2; 2 phalanges. AIM AR3156.1; 2 phalanges. *D. novaezealandiae*. AIM AR2964, AR3008; fragments identified by DNA analysis (McCallum et. al. 2013). MNI = 1. *Moa (Dinornithiformes)*. AIM archaeology collection; undiagnostic fragments (ca. 1340).

(b) Millener's site 96; location of finds in relation to above site uncertain. *P. geranoides*. AIM LB6253 (Moa 9, MOA16.3), coll. by V.F. Fisher 1934; R fem. MNI = 1. The identity of this bone was confirmed by DNA analysis (Huynen et al. 2010, Table S2). *Small moa (Emeidae)*. AIM LB6602 (Moa 8, MOA15.4), coll. by V.F. Fisher 1934; L&R fem (pair). MNI = 1. *D. novaezealandiae*. AIM LB6870 (Moa 98, MOA2.10), coll. by V.F. Fisher 1934; L tmt. MNI = 1.

Tairua

Archaeological site T11/62 (N44/2); Millener's site 100; midden (Smart and Green 1962, Rowland 1975). *P. geranoides*. CMC Av17153; L fem. CMC Av17172; proximal shaft fragment of R tbt. MNI = 1. *E. curtus*. CMC Av17156; distal part of L tbt. CMC Av17168; proximal part of L tbt. CMC Av17169; shaft fragment of L tbt. CMC Av17173; proximal part of L fem, distal part of R tbt. MNI = 1. **Small moa (Emeidae)**. AIM AU1947.16; parts of 2L fem. AIM AU1947.7; part of R fem. AIM AU1947.5; part of L fem. AIM AU1947.3; part of R tbt. AIM AU1947.7; phalanx. AIM AU1947.4; part of R tbt. AIM 2020.x.22; L fem (chick), distal end of L tbt. AIM AU1947.7; distal end of R fem. MNI = 3. CMC Av17155; proximal part of L fem. CMC Av17162; shaft of R fem. CMC Av17163; proximal part of L tbt. CMC Av17164; proximal part of L fem. MNI = 2. *D. novaezealandiae*. AIM AU1947.8; distal end of R tbt. AIM AU1947.27; proximal end of R fem. MNI = 1. CMC Av17154; proximal part of R fem. CMC Av17157; distal part of L tbt. CMC Av17158; vertebra. CMC Av17159; distal part of L tmt. CMC Av17160; distal part of L fem. CMC Av17161; 4 vertebrae. CMC Av17165; distal part of R tmt, 2 phalanges. MNI = 1. **Moa (Dinornithiformes)**. AIM archaeology collection; tracheal rings; undiagnostic fragments (97).

Opoutere

Millener's site 102; sand-dune. *P. geranoides*. AIM LB6023 (Moa 146, MOA8.10), coll. by R. Falla 1933; R tbt. MNI = 1. Labelled 'Wharekawa, Bay of Plenty' (= Wharekawa Harbour mouth, Opoutere).

Onemana

(a) Whitipirorua. Archaeological site T12/16 (N49/16); midden (Furey 1990; Jolly 1978). *D. novaezealandiae*. AIM AR158; fragment identified using DNA (McCallum et. al. 2013). MNI = 1. **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (ca 352).

(b) Jolly's Site 3. Archaeological site T12/26 (N49/33); midden. **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (59). MNI = 1.

Whangamata

(a) Whangamata Estuary. Dredged from sediments in harbour during marina construction; geological context uncertain.

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Small moa (Emeidae). *E. curtus* or *A. didiformis* (examined by BJG 2008), collected 2008, not in an institutional collection; L&R fem, part of tbt. MNI = 1.

(b) Whangamata Wharf. Archaeological site T12/2 (N49/2); Millener's site 105; midden (Allo 1972). *E. curtus*. AIM AR3757.1; part of L fem. MNI = 1. **Small moa (Emeidae)**. AIM AR2192; part of R fem. AIM AR3822; tmt (immature). AIM AR6344.5; part of R tbt. AIM 2018.x.268; L fem, 3 phalanges. CMC unnumbered, coll. by Durrant and Hockins 1961; undiagnostic bone fragments. MNI = 2. **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (17).

(c) Cabana Lodge. Archaeological site T12/3; midden (James-Lee and Gumbley 2012; Gumbley 2014; Gumbley and Laumea 2019). **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (61). MNI = 1.

Slipper Island

Archaeological sites U12/5 (N49/43), U12/9 (N49/48); midden (Rowland 1978). **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (6). MNI = 1.

10.07 Waihi Ecological District**Whiritoa**

(a) Archaeological site T12/500 (N53/4); Millener's site 106; midden (Foreman and Jolly 1965). *P. geranoides*. CMC Av20453, coll. by Jolly 1964; missing 2017. MNI = 1. *E. curtus*. CMC Av20454, coll. by Jolly 1964; shaft of fem. MNI = 1. **Small moa (Emeidae)**. CMC Av 20452, coll. by Jolly 1964; fragments of 1L&2R fem, 2L&1R tbt. MNI = 2. *D. novaezealandiae*. CMC Av20450; distal part of R fem. Av20451; distal part L tbt. Av20457, coll. by Jolly 1964; fragmentary tbt. AIM AU1745/1; fragment identified by DNA analysis (McCallum et. al. 2013). MNI = 2. **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (31).

(b) Archaeological site T12/497 (N53/1); midden (Crosby 1977). **Moa (Dinornithiformes)**. AIM archaeology collection; undiagnostic fragments (23). MNI = 1.

Waitekauri

Millener's site 109; surface find. **Moa (Dinornithiformes)**. AUG 7890, coll. by Mr Diamond 1979; presumed gastroliths (18).