

SHORT NOTE

Kea (*Nestor notabilis*) – another North Island human-caused extinction

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In historic times, natural populations of the endemic kea (*Nestor notabilis*) have been restricted to the South Island of New Zealand. Although there have been a few recent records of the species from the North Island, these have all been individual vagrant birds which may have originated from local captive populations (Cunningham 1974). In addition to these sightings, there is a single prehistoric record of kea from the North Island, described by Holdaway & Worthy (1993; Canterbury Museum AV 18389) from a cave in the Waitomo area. However, they concluded from its age (Otiran, Late Pleistocene), and the lack of Holocene (the past 11,700 years) fossils, that the species probably did not persist on the North Island following post-glacial climate warming that led to re-forestation. As kea mainly inhabit the subalpine zone and adjacent montane forest today, the largely forested North Island may have provided unsuitable habitat during most of the Holocene.

In this note we report 3 new fossil records that suggest kea populations did in fact occur on the North Island during the Holocene period, and have only become extirpated there after prehistoric human settlement.

The first record was discovered while re-housing the large Poukawa fossil bone collection in the Museum of New Zealand Te Papa Tongarewa (NMNZ) in 2001 - AJDT identified a left humerus (NMNZ S.18399) and a left ulna (NMNZ S.21509) as kea, using comparative material in the NMNZ collections. Poukawa is a lowland (21 m a.s.l.) wetland deposit in the Hawke's Bay, eastern North Island, that spans the last c.7,000 years (Horn 1983). Pollen evidence shows that in pre-human times the local vegetation was dominated by kahikatea (*Dacrycarpus dacrydioides*) forest (McGlone 1978). The 2 kea bones had previously been catalogued by P.R. Millener respectively as "*Nestor meridionalis* [kaka]...v.large" and "?*Nestor*...v.large". The humerus was from Site 2.64, Totara Point, and TP/29, either square 2, 11, 23 or 35, found on 16 March 1963 by T.R. Price *et al.* The ulna was from site 2.368, Totara Point, 3 inches below the Taupo pumice layer, undated, found by T.R. Price *et al.* The stratigraphic details for NMNZ S.21509 suggest that it predates the Taupo tephra deposited 1718 ± 5 years BP (Hogg *et al.* 2012).

On 14 September 2008, Clint Easton and LE collected 5 bones from coastal sand dunes just north of the Mataikona River, Wairarapa coast, which we identified as kea based on comparison with NMNZ specimens. It is unclear how many individuals are represented by the bones (NMNZ

S.45810), which include a premaxilla, right coracoid, proximal right humerus, right tibiotarsus, and right tarsometatarsus. This dune deposit is of Late Holocene age (Hay *et al.* 2008).

Several of these fossil bones are well enough preserved to obtain length measurements. Compared with ranges of measurements for reference kea and kaka (*Nestor meridionalis*) bones, the depth of the premaxilla and length of the humeri fall within the ranges observed for kea, but outside the ranges observed in kaka, which have deeper premaxilla and shorter limb bones (Table 1). The fossil ulnae, tibiotarsus and tarsometatarsus lengths are either as small as the smallest reference kea bone or between the ranges observed in kaka and kea. However the minimum kea and maximum kaka dimensions are very close to overlapping. Further research is needed to investigate why some North Island kea bones are smaller than those from South Island birds.

Holdaway & Worthy (1993) noted that the premaxillae of kaka have a ventral notch which is absent in kea; the Mataikona specimen lacks such a notch. The bicipital crest of both fossil humeri meet the bones' shafts gradually – a character used by Holdaway & Worthy (1993) to separate kea from kaka humeri. We found that the other humeral character used by Holdaway & Worthy (1993) to distinguish kaka and kea (whether the proximal margin of the incisura capitis was straight or notched) was unreliable as, with a larger sample size, we found it to be inconsistent between these species. The Mataikona tarsometatarsus has an elongate shaft and the axis of trochlea 3 is aligned with the main shaft; both of these are diagnostic characters for kea (Holdaway & Worthy 1993). Other diagnostic trochlea identification features were too worn to assess. The Mataikona tarsometatarsus is also slender (c.10.0 mm proximal width), giving a width to length ratio of 0.24; this is below the range for both kaka and kea but closer to kea (Holdaway & Worthy 1993). The only other large native parrot in New Zealand is the kakapo (*Strigops habroptilus*) but its bones differ substantially in both size and shape from those of kea and kaka.

Our identification of at least 3 new fossil kea individuals from sites in the Hawke's Bay and Wairarapa suggest that the species may have been an uncommon resident in the North Island during the Holocene. It is unlikely that these fossils represent vagrants as vagrants in the Holocene avifaunal fossil record of New Zealand are extremely rare, being almost entirely confined to beach-wrecked oceanic seabirds (*e.g.*, Holdaway *et al.* 2001). The Pleistocene kea specimen from Waitomo indicates that the species also inhabited the North Island before the Holocene period. Holdaway (1999: 223) noted that “massive climate shifts 10,000 to 15,000 years ago

resulted in perhaps two retractions of range from the North Island ([Haast's] eagle [*Aquila moorei*] and kea)”. However there is no longer evidence that Haast's eagle occurred in the North Island (Worthy 2000; Holdaway *et al.* 2001), therefore no bird species are now known to have retracted their range from the North Island as a result of climate change.

The lack of historical records of kea from the North Island indicate that the species probably became locally extinct prior to the 19th century. As there is no evidence of change in New Zealand avifaunal species diversity during the last 100,000 years, until the arrival of humans c.700 years BP (Holdaway *et al.* 2001; Wilmshurst *et al.* 2008), the disappearance of kea from the North Island was most likely due to prehistoric human modification of the environment. In the New Zealand archipelago the North Island bird fauna suffered the greatest losses as a result of human modifications (Holdaway *et al.* 2001). As with other New Zealand bird extinctions in the Polynesian period, the likely causes of this extinction are predation by Pacific rats (*Rattus exulans*) and humans (Holdaway 1999; Tennyson & Martinson 2007).

If kea had natural populations in relatively warm lowland North Island environments prior to human settlement, this challenges (though does not rule out) the widely accepted explanation that kea evolved as an alpine species in the cooler South Island and kaka only invaded the South Island in warmer post-Pleistocene times (Fleming 1975a, b, 1979; Bond & Bond 1999; Wood *et al.* 2014). Holdaway *et al.* (2001) postulated that ancestral *Nestor* may have evolved into kea and kaka lineages due to more subtle ecological differences but this may still have been driven by Plio-Pleistocene climate-caused habitat fragmentation leading to allopatric speciation (Rheindt *et al.* 2014). As with many New Zealand birds, the modern distribution of kea may simply reflect where kea survived human-caused extinctions. The abundance of Late Holocene (6,000–1,000 before present) kea fossil remains in lowland Canterbury, eastern South Island (*e.g.*, Holdaway & Worthy 1997), demonstrates that the species used to occur more commonly at lower altitudes in the South Island. Presumably this can be explained partly by higher predation rates on kea nests at lower altitudes (Elliott & Kemp 2004). Kea may therefore be a species that could be considered for reintroduction when restoring some of the former diversity of North Island ecosystems.

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Table 1. Measurements (mm) of North Island kea and reference datasets. Numbers in parentheses represent number of specimens measured.

			Kea		Kaka	
	Poukawa (NMNZ S.18399 and S.21509)	Mataikona (NMNZ S.45810)	Holdaway & Worthy (1993)	Wood <i>et al.</i> (2014)	Holdaway & Worthy (1993)	Wood <i>et al.</i> (2014)
Premaxilla length	-	c. 49	42.3 – 51.5 (8)	43.6 – 51.4 (12)	39.7 – 51.0 (14)	38.2 – 54.7 (16)
Premaxilla depth	-	12.7	11.6 – 13.3 (8)	12.5 – 14.9 (13)	14.0 – 18.7 (14)	14.8 – 18.8 (16)
Humerus length	73.5	73.4	73.4 – 81.2 (14)	73.7 – 83.6 (14)	54.8 – 65.2 (18)	55.8 – 66.2 (22)
Ulna length	c. 78	c. 80	80.0 – 88.3 (14)	80.8 – 90.5 (14)	63.3 – 73.6 (15)	61.9 – 74.2 (23)
Tibiotarsus length	-	c. 90	96.3 – 105.1 (14)	91.8 – 106.6 (13)	77.4 – 88.2 (14)	76.9 – 88.1 (22)
Tarsometatarsus length	-	c. 41	43.2 – 46.7 (12)	41.2 – 49.5 (13)	32.5 – 37.5* (15)	32.2 – 39.0 (25)

* Maximum length of 65.42 for North Island kaka given by Holdaway & Worthy (1993) is obviously a typo. We give the maximum value they present for South Island kaka.

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