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SHORT NOTE

Radiocarbon ages for two of the three South Island takahe (*Porphyrio hochstetteri*; Aves: Rallidae) from Pyramid Valley, North Canterbury, New Zealand

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Eleven bones of the South Island takahe (*Porphyrio hochstetteri*), seven representing a minimum of two adults and four from an immature bird, were excavated from the Pyramid Valley lake bed deposit (42º 58′ 22.54″S, 172º 35′ 50.12″E), near Waikari in the north-eastern South Island. Their presence in the deposit has been used as evidence that the big, flightless rail inhabited, or at least could inhabit, the lowland mixed forest/shrubland that surrounded the lake (Worthy & Holdaway 1996; Holdaway & Worthy 1997). This interpretation conflicts with the general view that the takahe is a relict glacial grassland specialist (Mills *et al.* 1984).

However, the undated presence of a species in a site whose environmental context may have changed with time does little to define that species' habitat preference(s). Takahe were among a minimum of 46 species of bird, whose habitat requirements ranged from forest to shrubland, grassland, wetlands, and open water, recovered from Pyramid Valley during excavations conducted periodically from the late 1930s to 1972 (Holdaway & Worthy 1997; Holdaway 2015). Until recently, radiocarbon ages had been measured on only the four species of extinct moa (Aves: Dinornithiformes) from the site (Allentoft *et al.* 2014; Holdaway *et al.* 2014). Without radiocarbon ages, even the relative dates of individuals are unknown because of the crude excavation methods, the fluidity of the sediments, and the lack of records of the recovery depths for the non-moa avifauna. The uncertainties of the chronology of species presence and an assumption of stasis in the vegetation make interpretations of when and in what habitat(s) the Pyramid Valley takahe may have lived difficult at best.

Radiocarbon ages on individuals are crucial because they allow species' occurrences to be referenced directly to their ambient vegetation. To provide a baseline for interpretation of habitat of takahe in the area around Pyramid Valley, I submitted bone samples from three individuals from the site — two adults, Av5922 (1.07 g), and Av15039 (0.41 g) (both from right femora), and the one juvenile, Av6041 (0.31 g) (tip of immature mandible) — for high precision accelerator mass spectrometry (AMS) radiocarbon analysis to the 14 Chrono Laboratory, Queen's University, Belfast, UK. The samples were chosen to avoid features of potential morphological interest. Collagen was extracted using a method based on that of Brown *et al.* (1988) but using a Vivaspin® filter cleaning method introduced by Bronk Ramsey *et al.* (2004). The conventional radiocarbon ages were calibrated to calendar date ranges via OxCal4.4, referenced to the SHCal20 curve (Hogg *et al.* 2020). The radiocarbon ages on the Waikari Cave and Takahe Tomo takahe (Table 1) were measured by the Rafter

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Table 1. Details of available conventional radiocarbon ages (CRA) on South Island takahe (*Porphyrio hochstetteri*), with calibrated (SHCal20 terrestrial calibration curve, Hogg *et al.* [2020]) mean and median dates Before Present (BP, 1950 CE), Before Common Era/Common Era (BCE/CE), and confidence intervals for the calibrated dates of the Pyramid Valley individuals. Av, Canterbury Museum accession number; S, Te Papa Tongarewa Museum of New Zealand accession number. Age, bird's estimated ontogenetic age at death. SD, standard deviation of radiocarbon measurement. $\delta^{13}C$, carbon stable isotope ratio used in calibrating measurement. Radiocarbon age sources: NZA, Rafter Radiocarbon Laboratory, GNS Science, Lower Hutt, New Zealand; UBA, 14Chrono laboratory, Queen's University, Belfast, United Kingdom. References: W & H, Worthy & Holdaway (1996); W, Worthy (1997).

							Calibrated dates BP			
Site	**Age**	**Museum no.**	**^{14}C Lab no.**	**CRA**	**SD**	**$\delta^{13}C$**	**Mean**	**SD**	**Median**	**Source**
Pyramid Valley	Imm	Av6041	UBA42952	1,680	26	-20.5	1,533	41	1,540	This paper
Pyramid Valley	Ad	Av15039	UBA42953	2,054	29	-22.6	1,963	37	1,960	This paper
Pyramid Valley	Ad	Av5922	UBA42954	Failed	-	-	-	-	-	This paper
Waikari Cave	?	S33717	NZA4612	3,480	100	-21.93	3,708	135	3,705	W & H (1996)
Takahe Tomo	?	S334493/ S33495	NZA6970	12,210	110	-20.5	14,154	246	14,108	W (1997)

						Calibrated dates BCE/CE		
Site		**Museum no.**	**^{14}C Lab no.**	**CRA**	**SD**	**Mean**	**SD**	**Median**
Pyramid Valley	Imm	Av6041	UBA42952	1,680	26	417 CE	41	410 CE
Pyramid Valley	Ad	Av15039	UBA42953	2,054	29	14 BCE	37	11 BCE
Waikari Cave	?	S33717	NZA4612	3,480	100	1759 BCE	135	1756 BCE

Confidence intervals for Pyramid Valley radiocarbon ages							
				BP		BCE/CE	
^{14}C age no.		**CRA**	**SD**	**68.3%**	**95.4%**	**68.3%**	**95.4%**
UBA42952	Imm	1680	26	1,583–1,518	1,589–1,452 (91.0%); 1,444–1,427 (4.4%)	368–432 CE	362–498 (91.0%); 507–523 (4.4%)
UBA42953	Ad	2054	29	2,004–1,983 (19.9%); 1,975–1,927 (48.4%)	2,043–2,030 (2.4%); 2,017–1,888 (93.1%)	55–34 BCE (19.9%); 26 BCE–23 CE (48.4%)	94–81 BCE (2.4%); 68 BCE – 63 CE (93.1%)

Radiocarbon Laboratory (now of GNS Science). All ages are reported by that laboratory according to the 1977 agreement on Radiocarbon Reporting Conventions (Stuiver & Polach 1977).

The radiocarbon age of 2,054 ± 29 ^{14}C years before present (BP) (UBA42953) was measured on one of the adults (Av15039, Table 1). Unfortunately, insufficient bone gelatin was recovered from the other adult's (Av5922) sample for measurement. As noted before (Holdaway & Worthy 1997), the immature bird confirms that takahe had bred at or very near the site: its radiocarbon age of 1,680 ± 26 ^{14}C years BP (UBA42952, Table 1) means that it lived 400 years after the adult (350–500 years taking the extreme upper and lower errors of both calibrated dates (Table 1)).

Only one other radiocarbon age on a takahe from the eastern South Island has been published. This was on an individual recovered from Waikari Cave, a small cavern at the south-eastern edge of the Hawarden Basin, North Canterbury, and 12.34 km east of Pyramid Valley. The Waikari Cave takahe was, at *c.* 3,700 calendar years BP (Table 1), also of Holocene age, but almost twice as old as those at Pyramid Valley (Table 1). The Waikari Cave fossil fauna included taxa with widely different habitats, from forest (e.g. New Zealand pigeon, *Hemiphaga novaeseelandiae*); South Island saddleback, *Philesturnus carunculatus*; South Island kokako, *Callaeas cinerea*) to shrubland/grassland (e.g., New Zealand quail, *Coturnix novaezelandiae*), and small shore and water birds (e.g., shore plover, *Thinornis novaeseelandiae*; New Zealand dabchick (*Poliocephalus rufopectus*) (Worthy & Holdaway 1996). Of the other radiocarbon ages for birds from Waikari Cave, two (NZ1723, NZ4166) can be ignored as they were measured on mixed bulk samples of small bones (Worthy & Holdaway 1996). However, an AMS age of 3,837 ± 71 ^{14}C years BP (NZA4613) on an extinct coot (*Fulica prisca*) (Worthy & Holdaway 1996) from Waikari Cave is almost indistinguishable from that on the takahe.

As none of other species from the site has been radiocarbon dated, they cannot be employed as indicators of the local habitat(s) available to the takahe. The variety of species (Worthy & Holdaway 1996) and their range of body sizes suggests that the deposit is an accumulation of the prey remains

of either or both the extinct harrier (*Circus eylesi*) and extinct laughing owl (*Sceloglaux albifacies*). The smaller birds could have been captured some distance from the site and might not reflect the vegetation near at hand occupied by larger species such as takahe, which are unlikely to have been carried far.

The Pyramid Valley (330 m) and Waikari Cave (220 m) deposits record faunas from relatively low altitude vegetation. The only other radiocarbon age for a South Island takahe is 12,210 ± 110 ^{14}C years BP (NZA6970) (Table 1) for one of six individuals identified in Takahe Tomo, a cave in the Hodges Creek cave system, at *c.* 940 m in northwest Nelson (Worthy 1997). The present vegetation in that area is southern beech (*Fuscospora*, *Lophozonia*, both formerly *Nothofagus*) forest. The bird is geologically much older than those from North Canterbury and was deposited during the period of warming following the most recent (Weichselian-Otiran) glaciation so its habitat probably included subalpine shrubland as well as grassland, fellfield, and encroaching beech forest, much as that occupied by the relict Fiordland populations.

The environmental context of the deposit at Pyramid Valley has been thought to be well understood (Moar 1970; Gregg 1972; Burrows 1989; Holdaway & Worthy 1997) and relatively constant. Recent work on the lake bed sediments and the fossil microflora has shown, however, that the present 1 ha lake is a remnant of a much larger (*c.* 50 ha) and deeper lake (Johnston 2014; Johnston *et al.* 2022). From *c.* 3,500 to 2,100 calendar years BP, the present Pyramid Valley lake was, apart from two brief intervals, a small shallow bay on the south-eastern periphery of a larger lake that filled the entire valley. The two dated Pyramid Valley takahe were deposited, one at the onset of, and the other at the termination of, the major change in the local vegetation that accompanied the lake's sudden drainage just over 2,000 years ago (Johnston 2014; Johnston *et al.* 2022).

The presence and disappearance of the lake means that the surrounding vegetation was not constant in extent or composition during the 3,500 years represented in the lake sediments (Johnston 2014; Johnston *et al.* 2022). The draining of the large lake exposed nearly 50 ha of the larger lake bed. In addition, the avulsing outbreak flood waters would have damaged or destroyed several square kilometres of forest in the outwash valley to the west and beyond that on the wide terraces along the upper Waipara River (Johnston *et al.* 2022).

The abrupt change in vegetation is recorded in pollen diagrams (Harris 1955; Moar 1970) but its significance was misinterpreted. Moar (1970) attributed the sudden rise in grass (Poaceae) and sedge (Cyperaceae) pollen at *c.* 400 mm depth to the replacement of forest by grassland after Polynesian firing (McWethy *et al.* 2010; McWethy *et al.* 2014), despite the continued abundance of forest tree pollen. A new age-depth model (Johnston 2014; Johnston *et al.* 2022) places the 400 mm depth at *c.* 2,000 BP and not at Polynesian settlement over 1,000 years later. At 400 mm, a spike in the terrestrial fern *Microsorum* (also known as *Phymatosorus*) (Harris 1955) was followed by another of bracken (*Pteridium*). The new date for the increase in grass pollen, along with the persistence of forest pollen (Moar 1970), suggests the colonisation of a significant new area of open ground within surrounding forest and recovery of forest destroyed further afield.

This new vegetation sequence means that the takahe adult was present when seral grassland and shrubland occupied the former lake bed and the regenerating forest to the west. In contrast, the immature bird lived 400 years later, by which time the succession to forest would have been complete and the entire valley forested. The species was therefore then breeding near Pyramid Valley – albeit unsuccessfully for the parents concerned – in lowland dry forest.

The calibrated dates for the two takahe suggest, but obviously cannot prove, that the species was present between the drainage of the large lake until forest had covered the former lake bed. The seral succession over those four centuries would have provided the species with a range of habitats from closed forest, to grassland near forest (as occupied by the birds surviving in Fiordland), and seral shrubland. The radiocarbon ages on these birds suggest that eastern populations of takahe were not restricted to "Pleistocene grasslands" but were flexible in their habitat requirements.

The source of the takahe population at Pyramid Valley, if indeed it was not present throughout the 5,000 years of the deposit's history (Johnston 2014), is unknown. As the species was present at Waikari Cave less than 15 km away 1,400 years before the first Pyramid Valley individual died, the South Island takahe may have been a regular, if uncommon, component of the North Canterbury Holocene avifauna.

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