Fossil deposits in the Hodges Creek Cave System, on the northern foothills of Mt Arthur, Nelson, South Island, New Zealand

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ABSTRACT

Avifaunas from Pleistocene and Holocene fossil deposits in the Hodges Creek Cave System in northwest Nelson, New Zealand, are described. At least 20 species of birds are present in glacial-age deposits from these sites at about 900 m above sea level. A sample of 12,000 year old Finsch's Duck (*Euryanas finschi*) bones shows that post-glacial shortening of the wings in this species had already started at that time.

KEYWORDS: Fossil avifauna, Holocene, Pleistocene, *Euryanas finschi*, northwest Nelson, New Zealand.

INTRODUCTION

Fossil avifaunas are particularly numerous in New Zealand cave, swamp and dune deposits up to 30,000 years old. Recent analyses of pre-existing and newly collected faunas have revealed not only the richness of this record, but that species were present in discrete associations whose distributions differed over this time (Worthy & Holdaway 1993; 1994; 1996; Worthy, 1993; 1997).

Caves provide the most important source of these fossil avifaunas because they 'sample' different habitats depending on, for example, whether they are in alpine grassland or closed canopy forest, and they sample faunas from a greater range of time than do dunes or swamps. Conditions in caves can favour the preservation and recovery of small delicate elements, especially compared to dunes where the sun and abrading sand combine to be highly destructive. In lakes, a lack of a concentration mechanism makes recovery of small elements difficult, whereas in caves slow sedimentation means fossils are often concentrated on the floor.

In northwest Nelson, the fossil faunas are particularly well known. Large and diverse faunas spanning 20,000 years are known from Honeycomb Hill at 300 m altitude in the west (Worthy & Mildenhall 1989; Worthy 1993), and many are known from up to 600 m in the Takaka area (Worthy & Holdaway 1994). Holocene faunas are known from the subalpine zone above 1200 m on Mt Owen and Mt Arthur (Worthy 1989). The described fossil faunas, therefore, do not adequately reflect higher altitude sites, and especially such sites from the Last Glacial period when glaciers covered areas above 1200 m on Mt Arthur and other northwest Nelson ranges. This paper seeks to redress this deficiency, and describes Glacial - Late Glacial faunas from sites in the Hodge Creek Cave System at about 900 m altitude on the flanks of Mt Arthur.

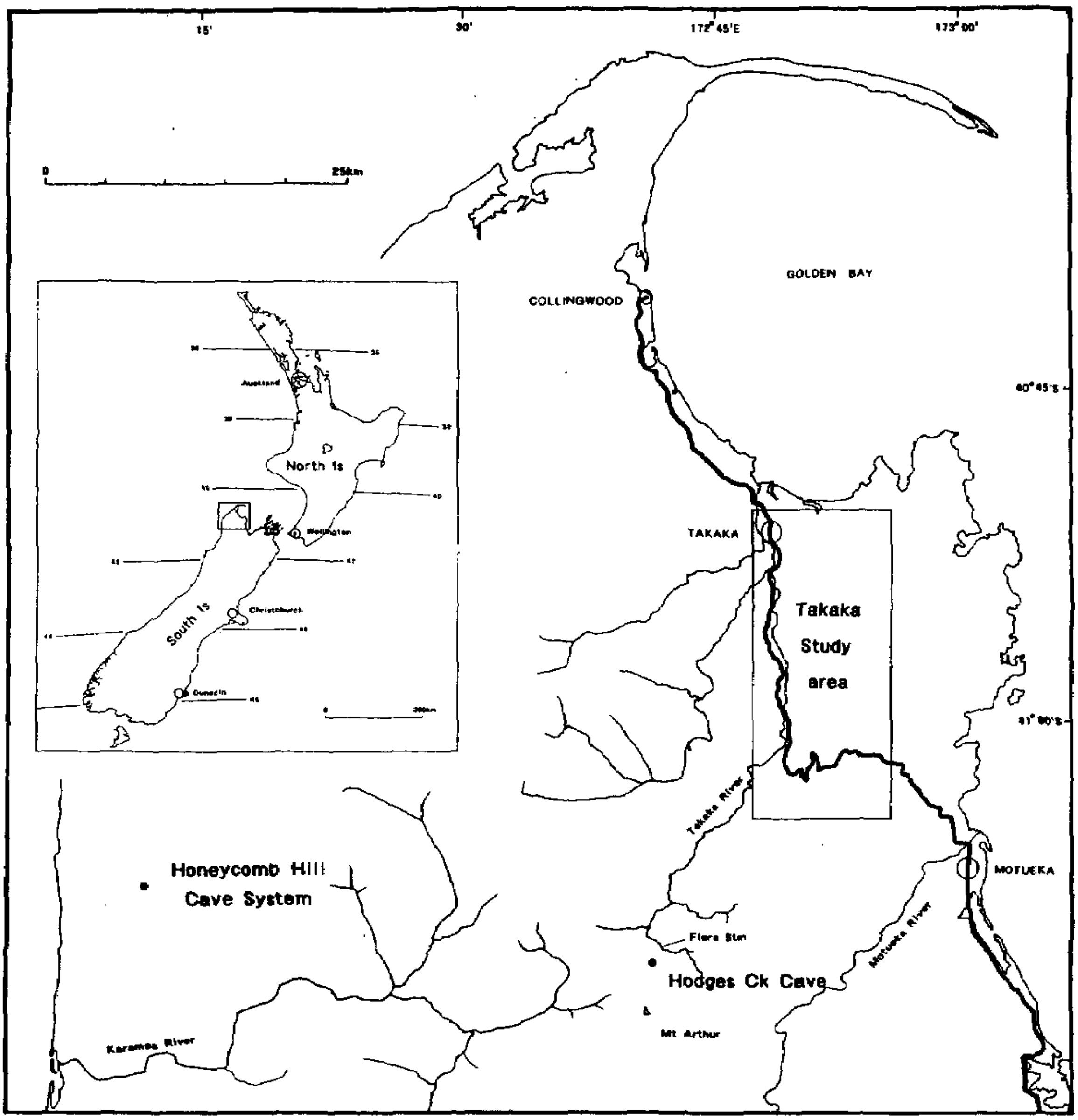

FIGURE 1 - Map of northwest Nelson, in relation to New Zealand. The study site Hodges Creek Cave System is located in relation fossil sites at Honeycomb Hill Cave System and the Takaka Study Area of Worthy & Holdaway (1994).

Site Descriptions and Methods

Hodges Creek Cave System lies in the headwaters of Hodges Creek, a tributary of the Flora Stream on the north side of Mt Arthur, northwest Nelson (Figs 1, 2). It is centred on the grid reference NZMS 260 M27 836039 at an altitude of 915 m a.s.l. It is a complex system with many entrances and unconnected cave passages.

I first visited the cave on the 6 June 1992, with Colin Bell, his daughter Kiri, and Roger Waddell. Numerous fossils were seen on that visit and some from the 'Stream Resurgence Section' were collected (Table 1). On subsequent visits the cave system was surveyed and fossil deposits investigated at various sites. Collected fossils are in

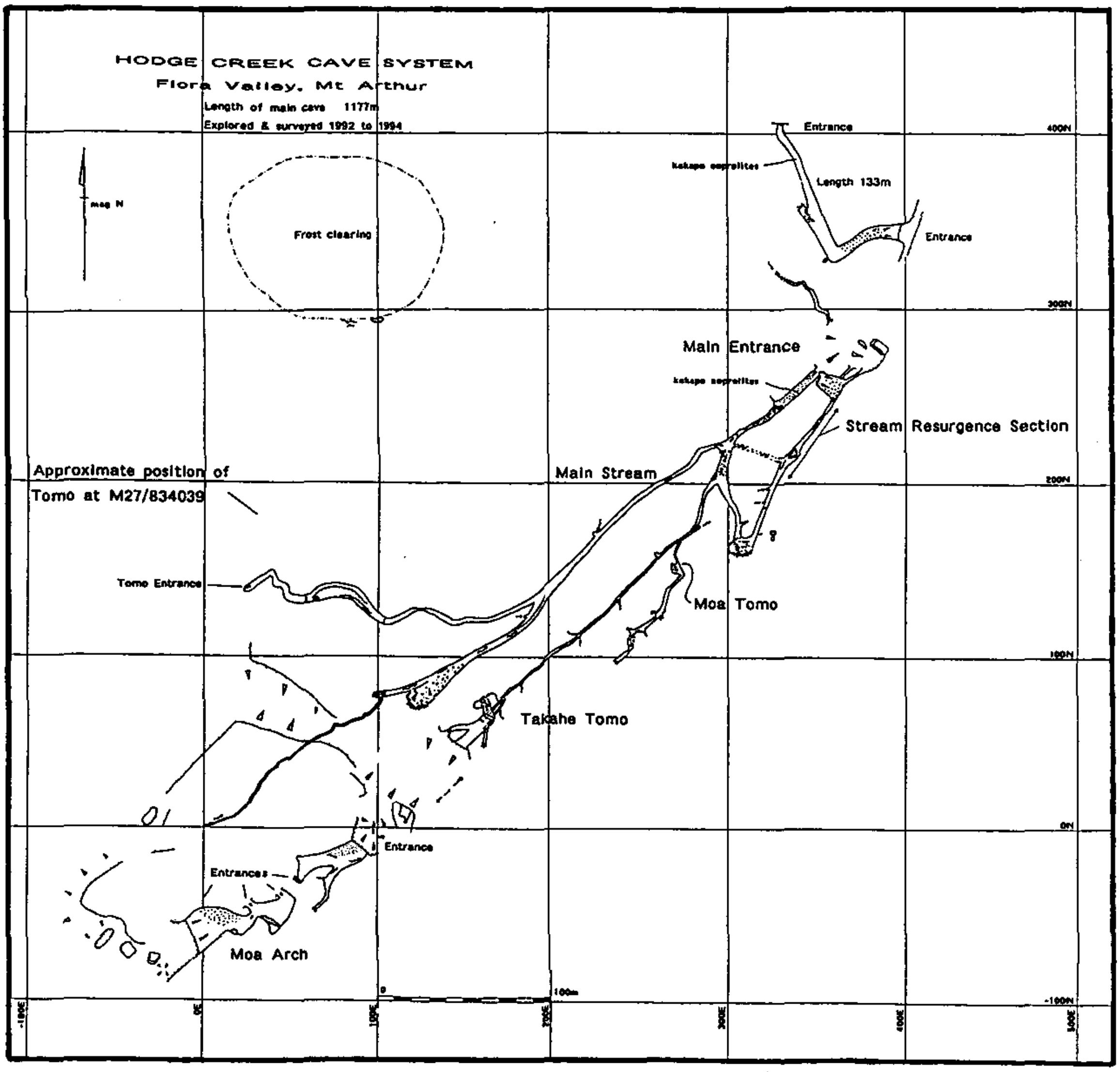

FIGURE 2 - A plan of the Hodge Creek Cave System overlain with a 100 m grid for ease of definition of specific points in the system. The grid has an arbitrarily chosen origin. Major fossil sites are indicated and the grid should be used to locate sites indicated in Table 2 and specimen labels.

the Museum of New Zealand Te Papa Tongarewa (MNZ) collection, or are temporarily with me. Cited ages are conventional radiocarbon ages (yrs BP, where BP is before present, which is by convention 1950) not calibrated to calendar years, obtained by Accelerator Mass Spectrometry (AMS) analysis of collagen extracted using a simple acid wash, further washed in acid and alkali, then the remaining sample dissolved to gelatin at 90°C under nitrogen and insoluble contamination removed by filtration.

I follow the nomenclature given in the New Zealand checklist (Turbott 1990) except that I follow Trewick (1996) in distinguishing North Island and South Island Takahe as distinct species as they were originally described.

This paper restricts its data to sites within the Hodge Creek Cave System as shown in Figure 2 and makes no attempt to incorporate data from sites in a nearby unsurveyed cave although numerous remains are present.

Three types of deposits were found in the Hodge Creek Cave System. An understanding of their origin is essential to the interpretation of the age and composition of the faunas.

1. Bones in Stream Gravels

In the Stream Resurgence section (Fig. 2) bones lay in the stream bed, some loose and others interred in consolidated gravels. Most of the specimens collected probably had their immediate origin from these gravel deposits. Many of the moa bones and some large Kiwi (*Apteryx* sp.) and Finsch's Duck (*Euryanas finschi*) bones were collected from within these gravels. Bones probably entered the cave via numerous pitfall traps upstream, in either of the two main branches, and were washed downstream to accumulate with sediment. This sediment is mainly preserved in the 50 m of passage immediately upstream of the resurgence entrance. There the slope of the passage is flatter - upstream, greater steepness has resulted in total scouring of the deposits although a remnant in the upstream section of the main branch attests to a former occurrence of these deposits as far as 270 m upstream of the passage start. In the first 50 m of passage loose slabs on the floor in the streambed provide a trap for bones and prevent them washing through the cave once eroded from the sediment.

2. Isolated skeletons on dry floors.

These can be any age post-dating the age of the surface on which they lie so are of little use in palaeofaunal reconstruction unless the individual specimen's age is known. Between the two stream passages and in various other places are sections of passage with no running water. Fossil snails and insect remains are present in the finer sediment on such floors.

3. Pitfall deposits beneath tomos

The cave has several entrances which drop vertically from the ground surface and, therefore, are effective pitfall traps. The significant ones are as follows:

Moa Tomo

Moa tomo is located about 15 m up the first side passage on the left of the minor streamway (270E 150N, see Fig. 2). It is a typical pitfall trap about 10 m in depth which opens from a narrow, hence geologically young, entrance. Moa bones are scattered on the floor at its base and others have washed up to 6 m down the rift leading towards the main stream.

Rockfall choke about 270 m up the main stream

At this site the passage is broad and rises up a rockfall to a choke through which a draft of air flows. These features, and the accumulated fossils here, indicate that beyond the choke a former entrance to the system was present in the past.

TABLE 1 - Fauna from the Stream Resurgence Section. After an initial assessment of the deposit I decided to collect only a representative series of the moa bones present. For this reason, mainly tarsometatarsi were collected with many femora and tibiotarsi left *in situ*. MNZ S are the MNZ catalogue numbers. Abbreviations are as follows: fem - femora, tt - tibiotarsi, tmt - tarsometatarsi, hum - humeri, cmc - carpometacarpi, L - left, R - right. MNI is minimum number of individuals represented. √ means bones present but not collected or quantified.

Species	In situ	MNZ S	Elements collected	MNI
Pachyornis australis	many	34450	2R5L tmt, 1 cranium	5
Megalapteryx didinus	some	34451	1L1R fem, 1L3R tmt	3
Dinornis struthoides	2R fem+	34452	2R tmt	2
Dinornis giganteus		34453, 34454	1L tmt, 1L fem	1
Apteryx australis/haastii		34469	2L tt, 1L tmt, 1L2R fem, part 4 pelves, 1 sternum	4
Apteryx owenii		34466	1L tmt	1
Porphyrio hochstetteri		34460	1R tmt, 1 pelvis	1
Gallirallus australis		34459	2L1R tt, 2 crania	2
Aptornis defossor		34461	1 sternum	1
Harpagornis moorei		34462	1 distal R tt	1
Nestor meridionalis		34465	1L hum	1
Strigops habroptilus		34457	2 pelves, 3L3R tt, 1L1R fem, 1 mandible, 2 crania, 1L hum, 1L cmc	3
Nestor notabilis		34467	1 sternum, 1L tt, ?L hum, ?L fem	1
Euryanas finschi		34458	4 pelves, 1 sternum, 5R2L hum, 1L tmt, 2R1L fem, 2L1R tt, 1L scapula	5
Anas chlorotis		34463	1 sternum, 1L fem, 1L scapula,	1
Hymenolaimus malacorhynchos		34464	1 cranium, 1 furcula	1
Pachyplichas yaldwyni		34470	1L hum	1
Callaeas cinerea		34468	1L tt	1
TOTAL			86	35
Capra hircus			loose in stream	√
Trichosurus vulpecula			loose in stream	√

Takahe Tomo

Takahe Tomo (160E 75N, Fig. 2) is at the back of a short unnamed cave. The tomo is about 2x1 m in cross-sectional area and drops from a room about 5 m wide. This room is exited via a rockfall sloping up about 5 m to the base of a rift with an entrance in its roof. Beyond this, the cave continues about 20 m on this level to a large horizontal entrance about 5 m wide. Takahe Tomo drops about 4 m from the room to a rockfall covered floor which slopes away about two metres to a small hole dropping into a small impenetrable streamway. The site is wet because of constant dripping water from overhead. Numerous bones were seen on the horizontal floor when the site was first visited, and investigations quickly revealed fossiliferous sediment remnants on two walls of the site. Opposite the point of entry a larger rift leads off, and sloping sediments emanating from it indicated this as the source of the sediments and fossils. The dripping water had eroded the sediment in the tomo creating a vertical wall 90 cm high at the entrance to the rift.

Bones were collected from this site on 25 May, 1995 by T. H. Worthy, G. Udy, and W. Blundell. All the lag material was collected first and kept separate. Secondly, a sample of the bones from the *in situ* uneroded sediments comprised of coarse granite sand was taken. Most of the *in situ* sample came from beside the rift in a remnant pocket preserved by overhanging rock. Little of the sediment within the rift was taken so presumably many fossils remain. The bones were very densely packed and the collected sample of bones was derived from only about 0.075 m^3. The *in situ* sediments were collected in bulk and wet-sieved later.

A small tomo at M27 834039

A small tomo containing fossil bones was found above the western margin of the cave, south of the frost-clearing in the forest (Fig 2). It almost certainly drains into the Hodge Creek Cave System. This tomo is about 6 m deep and is presently entered via a steep slope, and forms a slot about 8 m in plan length. Percolating water on the walls seeps away at the rear. The dripping water off the walls is eroding away a granitic sand/grit sediment that had partly infilled the cave and remnants of this can be seen on the walls up to 0.5 m above the floor, as well as in the floor of the last 2.5 m of cave passage. The fossils come from within this sediment infill which must originally have been at least 0.5 m thick.

Moa Arch

Moa Arch is a short cave remnant in which the northeast section is a chamber into which entry is via a vertical shaft tomo in the roof and two steep ramp-like entrances on the side. At present the site is not a pitfall trap, but in the recent geological past these latter two entrances were probably steeper and the chamber was probably effectively separated from the southeast section as far as fallen animals were concerned.

Moa bones lie on the cave floor in this arch in four discrete locations. None have been collected but all surface bones have been identified. I hope the fossils can remain as an *in situ* example of moa bone deposits. Only the robust leg bones survive: weathering having removed all the less dense elements such as vertebrae and pelves.

RESULTS

Bones in Stream Gravels

Most of the bones appear relatively old and the species composition (Table 1) is suggestive of a Last Glacial age for the deposit, as it compares well with deposits of this age elsewhere (Worthy 1993, Worthy & Mildenhall 1989, Worthy & Holdaway 1994). The lengths of Finsch's Duck wing bones from this deposit are within the range of Pleistocene bones from Honeycomb Hill but are longer than Holocene bones for which measurements are given in Worthy (1988b). However, at least one of the Weka (*Gallirallus australis*) bones and all the goat and possum bones, which

TABLE 2 - Fossils from scattered, isolated surface deposits in the Hodge Creek Cave System. Under Collection 'THW' means held by THW at present but eventual repository will be the MNZ, numbers prefixed by 'S' are MNZ catalogue numbers. The location is defined by eastings and northings on an arbitrary grid overlying the cave map (Fig. 2).

Species	Collection	In situ	Location
Dinornis giganteus	S34094-5 pt 1 skel		347E 264N, pt coll M. Polglaze 1975, pt by THW
Anomalopteryx didiformis		1 tibia	006E -049N
Megalapteryx didinus		skeleton	356E 343N
Megalapteryx didinus		1 tibia	060E -024N
Juvenile moa		3/2	330E 401N
Strigops habroptilus	THW - 1 skel	3 skel	3 at 302E 163N (1 coll); 1 on rockfall at c.125E 75N
Strigops habroptilus chick + eggshell	S34476 - part 1 chick and egg		314E232N
Cyanoramphus sp.	THW, 1 skel		283E 178N
Gallirallus australis		1 skel	218E 114N
Petroica australis	1. THW - 21/1 2. S34475 - 22/1		1. 284E 183N 2. 246E 106N
Anthornis melanura	THW - 33/1		301E 189N
Euryanas finschi	THW - 1 skel		85E 137N
Philesturnus carunculatus	THW - 1 skel		c. 25E 140N
Xenicus species	S34471 - 7/1		c. 25E 140N
Acanthisitta chloris	S34474 - 4/1		c. 25E 140N
Hoplodactylus sp. cf *granulatus*	S34472 - 1/1		c. 25E 140N
Leiopelma ? hamiltoni		several	Between 295E 200N and 305E 170N
Leiopelma ? hamiltoni	S34473 - 1/1		c. 25E 140N

were found loose in the stream, are very recent. Therefore, although most fossils may date from the Last Glacial, some will be of Holocene age.

Isolated remains on dry floors

Individual skeletons of several birds listed in Table 2 were collected and several small frog skeletons noted. The partial skeleton of a Giant Moa (*Dinornis giganteus*) recorded from the Main Entrance (S34094-5) was partly collected by Max Polglaze in 1975. Excavations in the sediment found additional parts of the skeleton, but most of the larger elements are missing and probably were collected by earlier visitors - people sluiced gold hereabouts in the 1930s. The excellent preservation of this skeleton, which was 2-3 m from the cave entrance, probably indicates that it is at most only a 1-3 thousand years old: bones of greater age would be expected to display significant weathering due to the seasonal wetting and drying they are exposed to in such sites. In glacial-age specimens from similar sites in Honeycomb Hill Cave only the most robust bones survive, the rest having crumbled to dust (Worthy 1993). The skeleton, therefore, probably represents a Holocene occurrence, which is

TABLE 3 - The fossil fauna of Takahe Tomo. Sxxxxx are the MNZ catalogue numbers; x/y is the number of bones / MNI, that were found either *in situ* in sediments, or as a lag deposit on the floor.

Species	In situ	Lag	Combined
Euryanas finschi	S34496 - 320/20	S34494 - 302/11	622/22
Porphyrio hochstetteri	S34495 - 52/5	S34493 - 78/5	130/6
Pachyornis australis	-	S34492 - 1/1	1/1
Apteryx ?haastii	-	S34491 - 2/1	2/1
Petroica australis	-	S34490 - 2/1	2/1
	Specimens		Catalogue No.
Philesturnus carunculatus	1L tt		S34480
Aegotheles novaezealandiae	1R tmt		S34481
Apteryx haastii	8/1 (includes skull, fem, tt, tmt)		S34483
Gallirallus australis	some bones		not collected

TABLE 4 - Species list from a tomo at M27 834039. Only voucher specimens were collected for the moa species present - many bones were left *in situ*.

Species	Specimens	Catalogue No.
Harpagornis moorei	7/1	S33634
Fulica prisca	pR tt	S34485
Apteryx haastii	1L tt 1R tmt	S34486
Euryanas finschi	1 sternum, 1R rad	S34487
Megalapteryx didinus	cranium, L ramus, R fem	S34488 (vouchers only)
Dinornis giganteus	3R fem	S34489 (vouchers only)

noteworthy as this species is very rare in Holocene deposits in Northwest Nelson (Worthy & Holdaway 1993, 1994; Worthy 1993).

Kakapo (*Strigops habroptilus*) coprolites identified by their characteristic shape (faeces of fibrous vegetable matter with the form of a tube about 0.5-1 cm diameter which is coiled upon itself to make a structure 2.5-3 cm wide and up to about 7 cm long) are also found as surface deposits in the cave system. They are present in the Main Entrance area and several other areas of the cave with dry floors. In a short isolated cave remnant to the east of the main system one accumulation of coprolites is nearly 0.5 m deep. In a small chamber, about 55 m from the Main Entrance, coprolites, eggshell and Kakapo chick bones indicated the former presence of a nest.

Pitfall deposits beneath tomos

Moa Tomo

Based on pelves (mainly) bones of one juvenile Large Bush Moa (*Dinornis novaezealandiae*), one adult Slender Moa (*Dinornis struthoides*), four Little Bush Moa (*Anomalopteryx didiformis*) and two Upland Moa (*Megalapteryx didinus*) are present. One of the Upland Moa is articulated in a sitting position. That both the Upland Moa are small, and that the only other species present are those listed, suggests this is a Holocene accumulation (Worthy 1988a, Worthy & Holdaway 1994). Four bones of the Large Bush Moa (S34456) and two of the Slender Moa (S34455) were collected in 1993.

Rockfall choke about 270 m up the main stream

Here bones of at least one of each of Slender Moa, Large Bush Moa, Crested Moa (*Pachyornis australis*) and Upland Moa are present and point to the proximity of an entrance now unattainable from within the cave. One of the Kakapo listed in Table 2 is from the rockfall here as well.

Takahe Tomo

The fauna of the *in situ* sediments comprised only two species, Finsch's Duck and Takahe (Table 3). The lag deposits on the floor of the tomo included in addition, a few bones of New Zealand Robin (*Petroica australis*), kiwi, and Crested Moa (Table 3) which are not necessarily the same age as the duck and Takahe bones which comprise the bulk. This is because the top of the tomo opens to a higher passage and thence to an entrance, introducing the possibility that bones may have entered the site from the top. In support of this suggestion was the presence of several bones of a large kiwi on the slope leading down from the rift entrance above about 2 m from the lip of the tomo. This kiwi was larger than, and duplicated the right femur found in the lag deposit, so represents a second individual. Also, a tibiotarsus of a Saddleback (*Philesturnus carunculatus*) and a tarsometatarsus of an Owlet-nightjar (*Aegotheles novaezealandiae*) were found on this slope. So, while it is reasonable to accept that all the Finsch's Duck and Takahe bones in the lag are derived from the original fill, it would be wrong to assume that the Robin bones were also from this source.

AMS dates were obtained from a left femur of a Takahe (*Porphyrio hochstetteri*) from -5 cm and a humerus of Finsch's Duck from -60 cm on the vertical face of the sediment in the inlet rift. The bone from -5 cm was 12,210±110 yrs BP (NZA 6970) and the bone from -60 cm was 12,100±120 yrs BP (NZA 6971). NZA 6970 had 11.3% insoluble residue removed at the gelatin extraction stage compared to 26.3% in NZA 6971. The higher proportion in NZA 6971 probably indicates a degree of humic contamination which if incompletely removed could be expected to make the age of the sample appear younger than it really is. Thus the lower sample is probably older than the date indicates, and therefore older than NZA 6970 whose age is the best date for the site. Nevertheless, it is unlikely that the real ages of these samples differ greatly and, therefore, relatively rapid (1-2000 yrs at most) accumulation of the sediments was likely. Rapid burial is supported by the fact that thin fragile bones such as the sterna and ribs and vertebra exhibit no wear such as expected in bones long exposed to running water in a streambed. Burial was not instantaneous, such as by some catastrophic event, because there was no articulation of bones as would be expected if many carcasses were deposited at once.

FIGURE 3 - A view of part of the moa bone deposit in Moa Arch, Hodge Creek Cave System.

The fauna from the tomo at M27 834039

The species composition of the fauna (Table 4) suggests very strongly that the deposit is of Last Glacial age as Haast's Eagle (*Harpagornis moorei*) and Finsch's Duck are not known from Holocene deposits of this altitude in Northwest Nelson (Worthy & Holdaway 1994). The consolidated enclosing sediments also support an older rather than younger age for this deposit.

Moa Arch

Moa bones are present in Moa Arch as follows.

1. In an alcove to the south of the tomo entrance is a remarkable assemblage (Fig. 3) of the following bones: Heavy-footed Moa (*Pachyornis elephantopus*) 2L2R femora, 2L2R tibiotarsi, 1L tarsometatarsi, 1 pelvis (10/2); Crested Moa (*Pachyornis australis*) 5R3L femora, 3R2L tibiotarsi, 2R tarsometatarsi, 1 pelvis (16/5);

2. In the centre of the chamber on the rockfall floor are a few scattered bones of: Heavy-footed Moa 2 pelves, 1L1R tibiotarsus;

3. Against the southeast wall of the chamber where periodic water flows disappear bones are jammed in rockfall debris: Heavy-footed Moa 1R femur, 1L fibula, 1L tibiotarsus, 1 vertebra (4/1); Crested Moa 1L tibiotarsus, 1L femur, 1R tarsometatarsus (3/1); Slender Moa *Dinornis struthoides* 1L tarsometatarsus (adult), 1L1R tibiotarsus (juvenile) (3/2);

TABLE 5 - Summary statistics for measurements (mm) of *Euryanas* bones from Takahe Tomo, Hodge Ck. Cave System. Abbreviations are TibTL - tibiotarsus total length, Cor - coracoid; others as for Table 1.

	Hum	Ulna	Cmc	Fem	TibTL	Tmt	Cor
Mean	92.10	76.06	51.33	67.62	106.06	53.46	45.86
Standard Deviation	1.81	1.86	1.52	1.95	2.75	1.25	1.06
Minimum	88.78	72.71	48.10	63.16	100.74	51.78	44.77
Maximum	95.84	80.10	54.22	72.40	111.27	55.70	48.63
Count	24	27	19	25	26	16	13
CV	1.97	2.45	2.95	2.88	2.59	2.34	2.30

TABLE 6 - Mean lengths (mm) for *Euryanas* bones from other sites, and the wing (humerus + ulna + cmc) / femur ratio. Data from Worthy (1988b). Abbreviations as for Table 5.

	Hum	Ulna	Cmc	Fem	TibTL	Tmt	Cor	wing/fem
Graveyard L2	91.01	75.67	50.83	65.21	102.2	52.02	45.16	3.34
Takahe Tomo	92.10	76.06	51.33	67.62	106.06	53.46	45.86	3.25
Kings Cave	82.69	67.6	43	62.6	97.8	49.71	-	3.09
Castle Rock	82.73	68.7	44.24	64.91	101.03	51.12	42.05	3.01
Martinborough	85.07	69.69	43.33	66.96	103.55	53.9	42.15	2.96
Waikari	82.7	68	-	64.4	99.9	51.1	-	-

4. At the northeast end of the chamber a slot below the entrance contains parts of a skeleton of the Stout-legged Moa (*Euryapteryx geranoides*).

This assemblage lacks the common species of Holocene faunas of northwest Nelson, i.e. Little Bush Moa and Large Bush Moa and the site would not act as a trap at present. These species are present in current traps nearby such as Moa Tomo (above) and other tomos in the vicinity (unpublished data). The composition of the Moa Arch fauna is similar to Moa Cave in the Oparara and other Glacial aged faunas (Worthy 1993; Worthy & Holdaway 1994), and is, therefore, inferred to be of Pleistocene age.

DISCUSSION

Faunal composition

The Hodge Creek Cave System contains deposits of Late Pleistocene (Otiran) and Holocene age. The 18 species listed in Table 1 are probably all represented in the Otiran fauna because of their association with Haast's Eagle, Adzebill (*Aptornis defossor*), Finsch's Duck, Crested Moa and Upland Moa. The Stout-legged Moa in Moa Arch and the Extinct Coot in the tomo with the Haast's Eagle bones are also probably part of the Otiran fauna. Finsch's Duck and Takahe were certainly present 12,000 years ago as indicated by their presence in the dated sediments of Takahe Tomo, and may have been two of the more common ground birds at that time if their

TABLE 7 - Length normalised means from other sites. Length-normal means were calculated by dividing bone lengths by the femur length from that site, which is shown under Fem. Abbreviations as for Table 5.

	Hum	Ulna	Cmc	Fem	TibTL	Tmt	Cor
Graveyard L2	1.39	1.16	0.78	65.21	1.57	0.8	0.69
Takahe Tomo	1.36	1.12	0.76	67.62	1.57	0.79	0.68
Kings Cave	1.32	1.08	0.78	62.60	1.56	0.79	-
Castle Rock	1.27	1.06	0.68	64.91	1.56	0.79	0.65
Martinborough	1.27	1.04	0.65	66.96	1.55	0.80	0.63
Waikari	1.28	1.06	-	64.40	1.55	0.79	-

frequency as fossils parallels life abundance. The majority of the species in Table 1 are typical of Late Glacial shrubland faunas as shown, for example, in Worthy & Holdaway (1994). The plateau in which the cave developed is presently about 900-950 m above sea level and during the later parts of the Last Glacial period glaciers would have extended down to about 1200 m on the flanks of Mt Arthur, two kilometres to the south. The Late Glacial faunas were probably living in an subalpine grassland/ shrubland close to permanent snow and ice.

Additional species of probable Holocene age include six listed in Table 2, Parakeet (*Cyanoramphus* spp.), Robin (*Petroica australis*), Bellbird (*Anthornis melanura*), Saddleback (*Philesturnus carunculatus*), wrens (*Xenicus* spp.), Rifleman (*Acanthisitta chloris*), and Owlet-nightjar (*Aegotheles novaezealandiae*) in Takahe Tomo, and Little Bush Moa (*Anomalopteryx didiformis*) and Large Bush Moa (*Dinornis novaezealandiae*) from Moa Tomo. In total, remains of 29 species of bird, at least one frog and a gecko were found. This diversity makes this cave system the most significant in the Mt Arthur area for its fossil deposits. Sites a little further north on Barron's Flat include Rua Ruru Cave which is significant for moas but not anything smaller, and Moonsilver Cave. There, only surface deposits occur and all are almost certainly Holocene in derivation so is not comparable to the Hodges Creek sites.

Of particular interest are the deposits of Kakapo coprolites. Their presence is related to dry preservation conditions and probably their not very great age: Kakapo lived in the Mt Arthur area up to the 1960s. They have an unexploited potential for Kakapo palaeodietary studies, and hopefully this note will incite some research interest. I know of places in Honeycomb Hill Cave in the Oparara, and in caves on the Garibaldi Ridge, where further deposits are present.

Comment on the size of the *Euryanas* bones in Takahe Tomo

Worthy (1988b) used the ratio of wing bone length to femur length to show that while the relative leg bone size (and assumed body size) remained unchanged over time, wing bones became reduced in size. The large sample of well-dated Finsch's Duck bones from Takahe Tomo allow testing of this observation. Summary statistics for Takahe Tomo Finsch's Duck are given in Table 5, and mean lengths of main wing

TABLE 8 - Percent Change in length normalised values from those of Graveyard Layer 2. Direction of change is shown by - reduced size, + increased size. These values were obtained by deducting the ratios for a given bone in Table 7 from that for the same element in the Graveyard sample, dividing the resultant figure by the ratio for the Graveyard sample, and multiplying this by 100. Abbreviations as for Table 5.

	Hum	Ulna	Cmc	TibTL	Tmt	Cor
Takahe Tomo	-2.16	-3.45	-2.56	0.00	-1.25	-1.45
Kings Cave	-5.04	-6.90	0.00	-0.64	-1.25	-
Castle Rocks	-8.63	-8.62	-12.82	-0.64	-1.25	-5.80
Martinborough	-8.63	-10.34	-16.67	-1.27	0.00	-8.70
Waikari	-7.91	-8.62	-	-1.27	-1.25	-

and leg bones are compared for various sites in Table 6. The lengths of Finsch's Duck wing bones from Takahe Tomo are not significantly longer than those from the Graveyard. However *t*-tests of the means show leg bones are significantly longer - femur $P<0.001$, tibiotarsi $P<0.01$, tarsometatarsi $P<0.01$. This suggests that the population around Takahe Tomo comprised relatively bigger birds than did that around the Graveyard. The relatively longer legs of Takahe Tomo birds results in a wing/femur ratio that is slightly smaller in Takahe Tomo birds than it is in Graveyard birds (Table 6) but still markedly greater than the other sites.

Castle Rocks, Martinborough and Waikari samples were taken to be Late Holocene in age while the Graveyard data given here is from Layer 2 which is 14,500 to 11,000 years old. Only one date (1470±50 yrs BP, NZ 4150) is available for the Martinborough site (Cave No. 1) from which the sample was derived, so conservatively these bones could be considered to be 1000 to 5000 years old. The Waikari fauna has, however, been better dated and is now known to be 1000 to 3000 years old (Worthy & Holdaway 1996). The Kings Cave fauna has also been dated (Worthy 1997), and is 1000 to 3000 years old. The Kings Cave data suffer from small sample size effects (humeri n = 10, ulna n = 4, carpometacarpi n = 3, femora n = 5, tibiotarsi n = 13, tarsometatarsi n = 6), as shown by the disproportionate reduction of the wing bone ratios compared to sites with large sample sizes. Therefore, the means may not be representative of the population. In summary, the Graveyard Layer 2 and the Takahe Tomo samples represent Late Glacial populations and the Martinborough, Waikari, Kings Cave and probably Castle Rock samples represent Late Holocene populations.

The length data given in Tables 6 and 7 can be represented as the percentage change the length normalised values differ from those of the Graveyard Layer 2. Direction of change is shown by - reduced size or + increased size (Table 8). Worthy (1988b) gave only the difference between ratios for each site from the Graveyard Layer 2 sample, and mistakenly called these percentage changes. The real percentage changes given here do not alter his conclusion that wings did reduce in length, but they allow refinement of the observation. For example, the direct changes in ratios did not reveal that the more distal elements of the wing were reduced to a greater extent than proximal ones. This would be expected if wing shortening was part of a trend towards flightlessness. In contrast, a species may reduce its humeri length in response to increased tree cover in the habitat, to effect wing shortening, but not flight loss. These percentage changes support the above contention that the Kings Cave values are probably somewhat unrepresentative, as carpometacarpi do not appear to have changed as expected from the more proximal elements and from consideration of data from the other sites.

A surprising result of this comparison is the observation that the sample from the 12,000 years old deposits in Takahe Tomo, in the Hodge Creek Cave System, showed a measurable reduction in relative wing length compared to the 11,000 to 14,500 years old deposits of Layer 2, Graveyard, Honeycomb Hill. Also the wing length, as measured by the sum of humerus, ulna and carpometacarpi mean lengths, divided by the femur length provides a ratio smaller than that for the Graveyard population, but markedly greater than those for the Late Holocene sites. As the sample from the Graveyard accumulated over a longer time interval than that from Takahe Tomo, there can be expected to be some 'time-averaging' effects in the Graveyard sample, therefore this data suggests that shortening of wings in Finsch's Duck had already commenced 12,000 years ago.

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