ARCHAEOLOGY IN NEW ZEALAND

STORAGE PRACTICES AND ENVIRONMENTAL CONDITIONS IN A CONTEMPORARY RUA KŪMARA AT OMAIO, EASTERN BAY OF PLENTY

MIKE BURTENSHAW [1], WIREMU TAWHAI[2,3], TEIRA TAWHAI[2] AND TONY TOMLIN[1]
1 OPEN POLYTECHNIC OF NEW ZEALAND, KURATINI TUWHERA 2 TE WHĀNAU O RUTAIA HAPU OF TE WHANAU-A-APANUI 3 TE WHARE WĀNANGA O AWANUIĀRANGI

Introduction

This paper describes the refurbishment and use of a contemporary rua kūmara in the Eastern Bay of Plenty and presents some preliminary results from data loggers used to record temperature and humidity in the rua during part of the storage season.

In their report on a specially constructed experimental storage pit at Seventeen Valley in Marlborough, Davidson, et al. (2007) commented on the sparse evidence available to archaeologists about many aspects of rua kūmara construction and function, such as how kūmara tubers were stacked, what materials were used for lining the pit interior and whether rua were heated inside with small fires. The paper then reported temperature and humidity records for the pit and an adjacent external control during the winter of 2004.

During 2007, Dr Mere Roberts introduced Mike Burtenshaw to Wiremu Tawhai and Teira Tawhai, who had constructed a traditional rua kūmara on their land at Omaio in Eastern Bay of Plenty, where they grow kūmara. Details of how the rua kūmara was constructed are described in an internal report by Mere Roberts and Wiremu Tawhai (2006) for the Mātauranga Māori and

Bio-Protection Research Team, National Centre for Advanced Bio-Protection Technologies at Lincoln University.

Wiremu recounted from memory details about storage practices in rua kūmara during his childhood. An informal interview was video recorded on 1 April 2009. His accounts are reported along with observations and descriptions of current storage practices as well as contemporary practice.

It was agreed to install data loggers to collect temperature and humidity records for comparison with the Seventeen Valley records of Davidson, et al. (2007). The data loggers were installed inside the rua and in an external control box on 5 April 2008 and set to record over the winter storage period.

The aim of the study is to add further comparative data about the environmental conditions inside rua kūmara, to highlight some of the differences between the Omaio pit and the Seventeen Valley subterranean storage pit and to address some of the questions raised in that experiment (Davidson, et al. 2007).

In this paper, we use the term rua kūmara in its broadest sense as it is used historically and contemporarily by Māori, not in the more restricted archaeological usage following Best (1974) which, as Davidson, et al. (2007:15) say, "is unfortunately well established in the archaeological literature to refer to a fully underground pit sealed by a lid or door". Wiremu states that underground pits of this type were called kopia and never referred to as rua.

Contemporary Practice

Observations on storage practices in a contemporary rua kūmara are reported below under subheadings. These observations include Wiremu Tawhai's recollections from his childhood about past practices used for managing rua kūmara.

Materials used in construction of the Omaio rua

The construction of the Omaio rua has been described by Roberts and Tawhai (2006). Since the primary purpose of this paper is to describe storage techniques and environmental conditions we will not repeat construction details. However, Davidson, et al. (2007) include a section on archaeological remains of material excavated from pits and therefore it is germane to mention the materials used in the construction.

Traditionally the two internal central posts and ridgepole would have been constructed of tōtara, *Podocarpus totara* D. Don or some other durable and strong native timber; however the ridgepole, two centre posts and corner posts at Omaio were constructed from a discarded telegraph pole of ground treated pine which was available at the time. The four corner posts, the rear main post and the central post are linked by rafters joined to the corner posts and the central ridgepole. This forms a stable structural framework that ties the ridge pole in place and supports the cladding materials. The four corner posts inside the pit only support the framework. The weight of the roof and cladding is transferred down to the earth side walls on which the rafters sit.

The first layer of roof cladding consists of the trunks of kaponga, silver fern, *Cyathea dealbata* [Forst. f.] Swartz. These kaponga log rafters rest on the ridgepole at the top and at the bottom on a kaponga log beam set into the bank atop the side walls. Thatch bundles of raupō, *Typha orentalis* C. B. Presl leaves were laid over this layer of kaponga logs and covered with a layer of soil 20–30 cm thick.

The front wall, into which the door frame and window were set, is also made from kaponga logs.

Rua preparation prior to storing the harvest

Cleaning the inside of the rua involved raking last year's lining material into a pile in the centre of the rua and burning it. The data loggers were not set to record at this time, but the intense heat generated by this fire was sufficient to warp their hard plastic casing. All old lining material was completely consumed and some heat disinfection effect may result from this fire. It certainly exterminates any insects that have domiciled themselves in the rua.

Bedding and lining material

Prior to harvest time kaponga fronds are gathered and dried. These are used as bedding on which the kūmara tubers are stacked, as lining to prevent contact between the tubers and earth walls, and to divide separate stacks of kūmara within the rua.

Various authors mention a variety of lining materials such as bracken frond, *Pteridium esculentum* (Forst. F.) Cockayne, clubmosses, *Lycopodium* spp., and mānuka, *Leptospermum scoparium* J.R.Forst. et G.Forst. var. *scoparium* as described by Davidson, et al. (2007). However, Wiremu uses both bracken and kaponga fronds as lining material depending on availability. As the storage season progresses, a multitude of spores are released from the sporangia of these dried kaponga fronds, covering the surface of the tubers with a golden brown film of spores. This may provide some bactericidal or fungicidal protection and is a topic deserving further research.

Curing the crop before storage

The crop is harvested when a long sunny spell is forecast during late February, March or April. In 2009 the Omaio crop was harvested on Good

Friday. There are traditional indicators used to make this forecast such as thin streaky, striated clouds running before the winds high in the sky, the song of the pipiwharauroa or shining cuckoo, *Chrysococcyx lucidus*, becoming shorter and losing intensity and finally stopping, certain white lines on the sea and the angle of the young moon, etc. Nowadays the television long range forecast can be added to this list. This time is preferred as sunny days are required after harvest to sun dry the crop before stacking it in the rua kūmara.

Selection of kūmara for storage

Selection involves keeping aside extra large kūmara for immediate use, as these contain more water and do not keep as well as average sized kūmara. The average size of the traditional cultivar 'Taputini' grown at Omaio is c.200 mm long by 40-50 mm in diameter. Likewise, any kūmara damaged during harvest are sorted for more immediate use. Such kūmara are given to whānau for immediate consumption or stacked last near the front of the rua kūmara for ease of access and first use.

Of prime importance is the selection of kūmara to be saved for seed. These tubers are sprouted in a seed bed to produce plants for next year's crop. This practice has long superseded the planting of one tuber per mound and probably dates back to the time when mouldboard ploughs were employed to form the long ridges into which the new plants are planted. The seed kūmara must be undamaged, sound tubers of typical shape and of average size for the variety being grown.

Stacking the kūmara

The floor of the rua is covered with a thin layer of small pebbles or gravel ranging in diameter from 10-20 mm. Over this floor on which kūmara will be stacked is spread a layer of dried kaponga fronds. A layer of the same dried fronds is placed against the earth walls of the rua before each section of kūmara is stacked.

Seed kūmara are stacked at the rear of the rua in a section separated from the rest of the crop by a lining of dried kaponga fronds. With the exception of the very large tubers which are not 'keepers', the large sound tubers are next stacked in a section, followed by a section of average sized tubers.

Tubers are stacked in rows starting against the side walls and progressively stacked out toward a central narrow path approximately 60 cm wide, which is left down the centre of the rua to allow access. As stacking proceeds the rows slope back toward the side walls. Each section on each side is separated by kaponga frond lining. The rows are individually stacked to the top of the side walls, which in this case is 1 m high. Any surplus crop unable to be stacked in the rua is dispersed among whānau and helpers. This includes any broken and damaged kūmara that are always stacked last.

Inspection, access and light levels

The Omaio rua kūmara is set into an embankment with steps leading down to the centrally positioned door, which is 1.8 m high and faces north. The steps are external to the pit itself. A door of this size allows easy access to inspect stored kūmara and when open allows sufficient light to inspect tubers close to the door. Any with signs of suspected rot can be taken to the light of the doorway for closer inspection. At Omaio inspection of tubers is not as problematic in terms of light levels and access as described for the Seventeen Valley storage pit (Davidson, et al. 2007).

However, he way the rows are stacked up from the side walls out toward the central aisle means that most of the crop stacked at the back and bottom cannot be inspected without dismantling the stacks and restacking. Wiremu states that there were always regular inspections of the stored kūmara and that there was strong reliance on smell to detect the unusual odours that rotting kūmara give off. If a rotted kūmara was detected then the stack in that vicinity might be unstacked and restacked after inspection. It should also be remembered the volume of stacked kūmara for eating diminishes after each meal. Normal practice is to use any kūmara tubers showing signs of deterioration by removing any areas of rot and using this portion first.

Ventilation

The Omaio rua kūmara has a ventilation hole called a putanga kāpuni above the doorway and the tāhū (central ridgepole) slopes slightly upward from the rear to the front. This allows air to circulate and helps to regulate humidity levels. It would also allow any smoke from a small fire or embers to escape if the door was closed. Wiremu remembers seeing steam issuing from the putanga kāpuni and from the opened doors after the crop was stacked as it cured. The doors were regularly opened in the first few weeks after harvest in warm sunny weather.

Heating

Although he had never seen it done, Wiremu recalls the old people of his youth talking about placing charcoal embers or hot stones in rua kūmara on very cold nights and remarked that the people knew which species of wood embers smoulder and give off more heat than others. With a ventilation hole for the smoke to escape from, such a fire or hot coals could safely be placed in the central aisle of the rua kūmara. There was active management of rua kūmara during the winter months.

During construction Wiremu set a fire inside the rua kūmara in order to determine, by the egress of smoke, if there were any gaps that needed plugging in the kaponga slab and raupō thatch roof before the earth capping was placed on top.

Dimensions and volume of stored crop

Wiremu states that the dimensions for building of a rua would be determined by kaumātua and experts based on the expected size of the crop. There were generally no fixed dimensions for rua construction. The Omaio rua kūmara is 3 m long but is not exactly rectangular. The back wall is 2 m wide and the front 1.8 m wide. The height of the side walls is 1 m. At this level the roof sloping down from the tāhū (ridgepole) meets the side walls. This constitutes the base storage area available. The volume of this base storage area is 5.7 m^3. The pou muri (back post) supporting the ridgepole is 2 m above the floor and the pou mua (front post) 2.5 m above the floor giving the ridgepole a backward slope. The volume of the roof space is 3.6 m^3, giving a total internal air space of 9.3 m^3.

Provided enough crop was produced, the kūmara tubers would be stacked in the base storage area to a height of 1 m, to where the roof meets the side walls. A central access aisle 0.6 m wide runs the entire length of the rua to the back wall taking up 3 x 1 x 0.6 m = 1.8 m^3 of the base storage space. The total potential storage volume for kūmara tubers in the rua is 5.7 m minus 1.8 m, or 3.9 m^3.

Approximately 68% of the base storage area and 40% of the total 9.3 m^3 of internal space in the rua might be occupied by stacked kūmara tubers. Air circulation is provided down the central aisle and above the stacks in the 3.6 m^3 of roof space. Combined with the ventilation hole (putanga kāpuni) above the doorway this provides effective ventilation. It would be possible to use some of area of the aisle for storage initially, provided that these were the first tubers removed for food in early winter. As Davidson, et al.(2007) point out, 57.8 % by weight of the stacked kūmara tubers is taken up by voids or air spaces between the tubers and this must also be considered when calculating storage volumes.

Temperature and humidity records from the data loggers

Method

Two data loggers were placed inside the rua kūmara attached to the rear post at a height of 100 cm above floor level and two identical data loggers in a control box on a post outside at the same height above ground level. One was a two channel temperature logger for recording air temperature in the logger and soil temperature from a temperature probe buried 30 cm deep in the soil. The second logger recorded relative humidity and temperature. The air temperature and relative humidity sensors were mounted 100 cm above the soil surface inside the pit and at the same height in the control box on a post outside.

Unlike the Seventeen Valley experiment where the data loggers were set to record at two minute intervals, the data loggers at Omaio were set to record at ten minute intervals. This allowed a longer time interval between downloads while still providing an accurate record of shifts in temperature and humidity.

The data loggers were started on 5 April 2008 and the first download of data occurred on 3 September 2008. One hundred and fifty-three days of records were obtained. Owing to an error in resetting the data loggers no further data was recorded after 3 September.

Results

The records from 5 April through May, June, July and August provide data over a similar period as the records from the Seventeen Valley pit of 2004. Here we highlight some of the similarities and differences between 2008 at Omaio and 2004 at Seventeen Valley but do not attempt any detailed analysis. Through the 2009 winter we have had data loggers recording at both sites and this will permit a more valid comparative analysis to be undertaken and reported at a later date.

Table 1 shows the temperature statistics for the four data loggers derived from 21,711 ten minute interval samples at each data logger. The temperature inside the rua ranged from 8.6 to 20.9°C, falling below 10°C on three nights, 7, 8 and 9 July as can seen in Figure 1.The outside temperature ranged from -1.4 to 32.3°C. Of particular note are the 80 days on which the external temperature fell below 10° C outside. The moderating influence of the rua environment is obvious.

	Inside air	Outside air	Inside soil @30cm depth	Outside soil @30cm depth
Max (° C)	20.865	32.278	18.247	20.746
Min (° C)	8.643	-1.355	13.786	8.394
Average (° C)	13.758	12.378	15.488	13.245
St. Dev. (σ)	2.316	5.281	1.275	2.715
Days < 10° C *	3	84	0	10

*Table 1: Temperature Statistics over 153 days from 5 April to 4 September at Omaio. * Number of days on which the temperature fell below 10° C during the day.*

Figure 1 demonstrates the influence of the rua in moderating the diurnal variation and the lag time in reaching minimum temperature inside the rua. This is much the same as in the records from Seventeen Valley although the minimum temperature reached there, 5.8°C versus 8.6°C at Omaio, clearly reflects the climatic differences between Marlborough and Eastern Bay of Plenty. An important difference is the percentage of the total time period during which the temperature inside the pits fell below 10°C: 54.4% at Seventeen Valley and less than 1.5% (3 days) at Omaio.

As well as moderating the temperature fluctuation, the rua moderates diurnal fluctuations in relative humidity (RH), as can be seen in Figure 2. The relative humidity statistics are presented in Table 2. As might be expected, the minimum RH inside the rua occurred when the rua door was open during inspection and it is possible to ascertain the days on which people entered the rua for any length of time by the sharp drops in RH.

	Inside relative humidity	Outside relative humidity
Max (RH)	98.582	98.358
Min (RH)	73.446	32.254
Average (RH)	94.108	83.118
St. Dev. (σ)	2.097	10.808

Table 2: Relative Humidity Statistics over 153 days from 5 April to 4 September at Omaio.

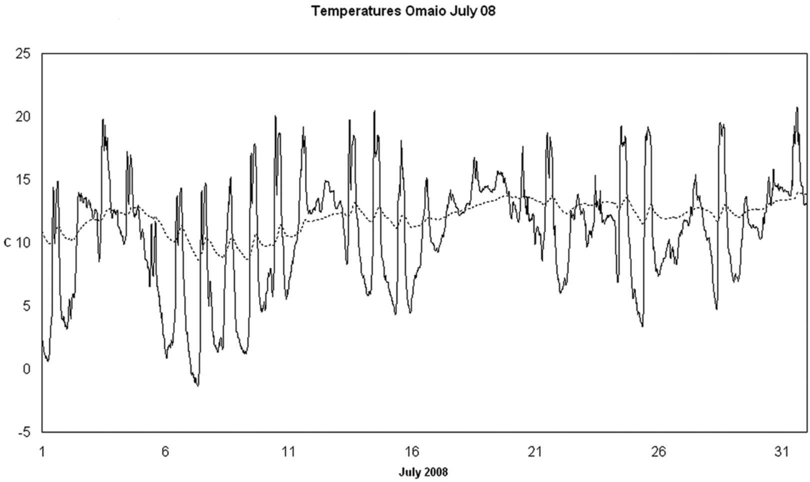

Figure 1. July 2008 external temperature (black line) and internal rua temperature (dashed line) at Omaio.

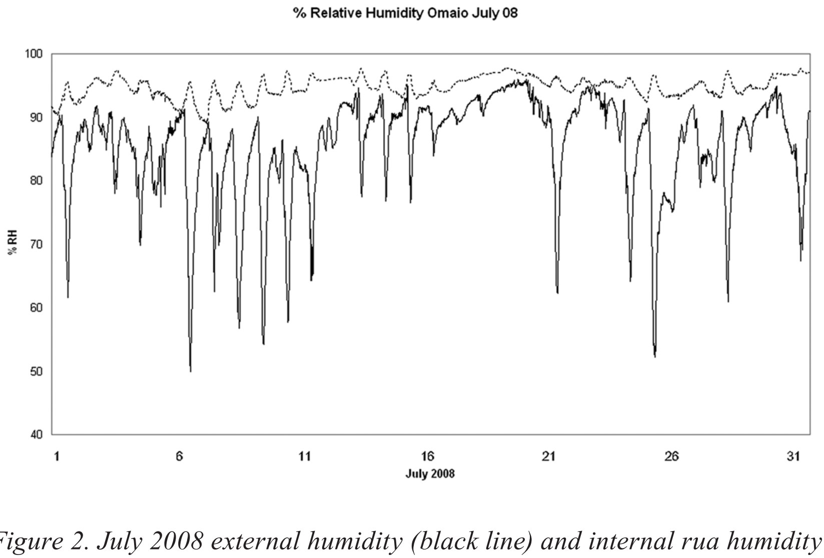

Figure 2. July 2008 external humidity (black line) and internal rua humidity (dashed line) at Omaio.

Conclusions

Unsurprisingly, the management of a rua kūmara at Omaio is less difficult than in areas marginal for kūmara production like Marlborough. The natural climate advantage of Eastern Bay of Plenty means crops can be stored in rua and will last well through the winter. In fact there were still kūmara in the Omaio rua at Christmas 2008 and all the authors enjoyed these at their respective Christmas dinners.

When the latest results from the pits at Seventeen Valley and Omaio are analysed for 2009 we should be able to establish a rule-of-thumb formula for estimating the environmental conditions within any typical rua given external temperature and humidity records.

While we cannot say with any certainty that the contemporary storage practices and those remembered and reported by Wiremu Tawhai apply to the situation that existed for pre-contact Māori agriculture, it is hoped that the practices reported here relating to rua preparation, curing, selecting and stacking kūmara, ventilation, heating, dimensions and volume and materials used in constructing the Omaio rua kūmara will allow the archaeological community to better interpret and understand subterranean storage pits.

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