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The archaeobotany of Rapan rockshelter deposits

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Introduction

Archaeobotanical records are becoming increasingly important in resolving several issues in the archaeology of Remote Oceania. Robust chronologies for island colonisation have been constructed for a number of islands through direct dating of plant materials with low inbuilt radiocarbon ages (e.g. Allen and Wallace 2007; Wilmshurst et al. 2011). The nature of biological introductions is better understood from abundant introduced plant remains found in archaeobotanical records (e.g. Kirch et al. 1995; Weisler 1995; Orliac and Orliac 1998; Burney et al. 2001; Allen and Wallace 2007). Increasingly, phytolith and starch grain analyses are being used as a first measure of plant use and exploitation for archaeological deposits without macrobotanical remains (e.g. Horrocks and Weisler 2007). Macrobotanical remains have been excavated from numerous sites in Remote Oceania, but surprisingly few attempts have been made to identify these plant remains.

Excavations of rockshelter deposits from Rapa (Figure 4.1) have produced abundant archaeological remains (Chapter 3). Here we describe the plant remains excavated from all the rockshelters, concentrating on the largest deposit at Tangarutu, Anarua Bay. Following the methodology of Allen and Wallace (2007), we compare radiocarbon dates obtained from young wood and seed remains as a means of excluding the potential inbuilt age effect from dating unidentified wood charcoal (e.g. Anderson 1991). We then compare the archaeobotanical data with other major excavations conducted in the Cook-Austral region. Finally, an ethnobotanical synthesis for the main plant species in the assemblages is provided. As the use of the plants identified within these deposits has changed since European colonisation, interpreting the

significance of the remains is complex and is done here in reference to the ethnobotanical notes of Stokes (n.d.) gathered from Rapan informants, 1921–1922.

Vegetation history and archaeobotany

The vegetation history of Rapa has been described by Prebble (In press) and is discussed here in the context of interpreting the archaeobotanical record. Stokes (n.d.) described extensive agricultural production along some of the embayments and surrounding hill slopes and documented the abandonment of traditional land-use practices in many parts of the island due to population decrease and the increased importation of goods and services. The numerous dry-stone bund features that line many of the valley floors indicate formerly extensive *Colocasia esculenta* (Araceae) agriculture. Small pockets of tree crops introduced before European contact, such as *Aleurites moluccana* (Euphorbiaceae), *Ficus tinctoria* (Moraceae), *Musa* spp. (Musaceae) and *Cordyline fruticosa* (Laxmanniaceae), also reflect the former importance of traditional land use. The abandonment of horticulture and arboriculture complicates the interpretation of the archaeobotanical record, given the lack of vegetation available for comparing and interpreting modern and past plant use.

Environmental degradation of the island is most apparent in the valleys adjacent to the coastal rockshelter excavations at Angairao and Akatanui and the upland rockshelter at Taga. These valleys, denuded of local vegetation, show abundant signs of long-term abandonment of *Colocasia* agriculture and are overrun with feral horses, cattle and goats. Taga rockshelter lies at ca. 150 m elevation above the head of Ha'urei Bay and is surrounded by eroding embankments and entirely exotic shrub and grass vegetation sustained by feral grazing animals and regular human-lit fires. The present vegetation within each valley varies considerably, primarily as a function of differing scales of human impacts across the island.

Tangarutu rockshelter is on the south side of Anarua Bay behind a boulder beach. Indigenous trees including *Pandanus tectorius* (Pandanaceae), *Fagraea berteriana* (Loganiaceae), *Glochidion* spp. (Euphorbiaceae), *Myrsine* sp. (Myrsinaceae) and Rubiaceae species are found in small pockets along the coastline of Anarua Bay. Larger stands of indigenous plants are restricted to the ridgelines or inaccessible gulleys at the head of the valley. Agricultural activity has been abandoned in the bay and bund terrace features are now covered with exotic and invasive vegetation (e.g. *Syzygium jambos* and *Psidium gjuava* in the Myrtaceae). The dominant

Figure 4.1. The Central Pacific, showing the location (circled) of the main islands mentioned in the text.

secondary vegetation at Anarua Bay, adjacent to Tangarutu rockshelter, is mostly of exotic tree, shrub and grass species. Driftwood lines the boulder beaches after storms and no doubt provided fuel to people inhabiting the coast.

Palaeoecological analysis of swamps in the Anarua, Akatanui, Iri and Angairao valleys provides only limited information about vegetation change during the period of human occupation, as the preservation and diversity of plant remains was limited in the swamp deposits examined. By contrast, rich swamp deposits at Tukou, in Ha'urei Bay, reveal that lowland vegetation was considerably more diverse before human colonisation and was quickly removed in the process of establishing agricultural fields for *Colocasia esculenta* (Kennett et al. 2006; Prebble In press). Based on the palaeobotanical evidence at Tukou, forest resources available to the initial colonists would have varied little across each valley. On initial colonisation, people would have encountered large *Pandanus*-dominant coastal swamp forest built up along riverbanks and behind the boulder beaches. Along the inland margins of these swamp forests were lowland forest trees and shrubs, including an extinct palm (Arecaceae), *Celtis pacifica* (Ulmaceae) and *Glochidion* spp. Sedge and rush wetlands, dominated by *Schoenoplectus subulatus* var. *subulatus* and *Eleocharis* spp. (both in Cyperaceae), would have persisted within the more permanently swampy areas, particularly along the margins of the *Pandanus* forests.

The rockshelters and preservation of plant remains

With the exception of Tangarutu, the coastal rockshelters are less than 10 m in maximum dimension and do not preserve large amounts of plant remains. The elevation of the coastal rockshelters varies from site to site, with all the shelter floors lying at least 2 m above sea level. Shelter entrances are usually behind large boulder beaches away from storm wave action or tidal surges. There is no evidence of major disturbance from coastal influences at any of the rockshelter sites. There is also no evidence to suggest that any archaeobotanical deposit is derived from beach drift, other than in material brought into the site by humans, but some remains of *Pandanus* or other plants growing near the shelter entrances might have entered the sites naturally. All shelters consist of a basaltic platform with overlying calcareous beach or dune sands, including coral pebbles and occasional boulders that have been accumulating, probably, since the mid-Holocene sea-level high stand of up to 2 m above present levels (Dickinson 2001). Most shelter floors (e.g. Tangarutu west section) show signs of recent alluvial and colluvial sedimentation, with incised channels stretching along the front of the inner face of each shelter. Reddish brown basaltic sediments associated with this channelling appear to be derived from the talus hill slope above the buttress of each shelter. The dry beach sands are partly covered by an overburden of these in-washed sediments. Despite this recent sedimentation, most deposits are dry and preserve plant materials with little evidence of diagenesis through periodic inundation and oxidation.

The excavations

Excavations on Rapa concentrated on coastal rockshelters, as they were expected to yield the best evidence of initial habitation on the island, and therefore of initial plant use. Compared with Tangarutu, excavations at Akatanui, Angairao and the upland shelters at Taga exposed shallow stratigraphy with a low abundance and diversity of cultural material and plant remains. Plant remains were recovered by hand picking during dry sieving (3 mm mesh) or as individual finds from different layers, particularly of leafy material. The base of the Angairao rockshelter stratigraphy dates to ca. AD 1350–1250 (Chapter 11), which is essentially the same as the

oldest age at Akatanui, while the rockshelter at Taga suggests later occupation of this upland site. The Akatanui sequence is more indicative of continuous occupation from ca. AD 1350–1450 up to the period of European colonisation, marked by introduced materials (e.g. glass). Apart from Tangarutu, archaeobotanical remains were richest at Akatanui, with abundant wood charcoal fragments and *Aleurites moluccana* endocarps in cooking oven deposits. A summary of the archaeobotanical remains found at Akatanui, Angairao and Taga, including charcoal and endocarp abundance, is presented in Table 4.1, with radiocarbon ages from plant remains presented in Table 4.2.

Table 4.1. Plant materials including unidentified charcoal and *Aleurites moluccana* endocarps obtained from the Angairao rockshelter E, 2nd oven.

Spit/depth (cm)	Charcoal (g)	<i>Aleurites moluccana</i> endocarp (g)	Other (g)
Spit 3/20–30	4.18	–	23.31 (ash)
Spit 4/30–40	1.41	–	–
Spit 5/40–50	1.55	–	–
Spit 6/50–60	2.98	0.30	–
Spit 7/60–70	5.70	0.33	–
Spit 8/70–80	1.52	–	–
Spit 9/80–90	2.38	0.21	–
Spit 10/90–100	2.61	0.15	0.14 (leaf)
Spit 11/100–110	<10		

Table 4.2. List of radiocarbon dates on unidentified charcoal obtained from the Angairao Rockshelter E, 2nd Oven.

Sample/depth (cm)	Weight (g)	Lab code	C14 age (uncal.)	2 s cal. AD
E1 Spit 10/90–100	20	ANU 11851**	500+/-50	1394–1618
E1 Spit 11/100–110	<5	UCI 14767*	375+/-15	1487–1627
E1 Spit 11/100–110	<5	UCI 14766*	220+/-20	1653–1803

Presented are the sample depths, radiocarbon laboratory (UCI=University of California Irvine; ANU=The Australian National University), weight of charcoal dated/the amount of charcoal found in spit, laboratory sample codes, uncalibrated determinations (*AMS, **conventional) and calibrated ages to 2s. Dates were calibrated using the program Calib 6.0. (Stuiver et al. 2005) using the Southern Hemisphere Calibration Curve (McCormac et al. 2004).

The Tangarutu sequence

The Tangarutu rockshelter at Anarua Bay is of such a notable size (80 m x 40 m) that it is likely to have been used from the earliest period of settlement. Small test excavations on the rockshelter beach sand at the southern end of the shelter by Walczak (2001, 2003) produced calibrated radiocarbon dates between AD 1450 and 1700 (Ly-8577 and Ly-8578, see Chapter 11). Since Walczak's excavations, a large amount of archaeological material has been removed in the process of extracting sand for building projects. This may have resulted in the destruction of most of the archaeological deposit. During the 2002 expedition, the remaining undisturbed deposits towards the back of the shelter were sampled with a sand auger and about 4 m² of the deepest and richest deposits were excavated.

The east section of the shelter revealed the deepest archaeological deposit on the island, with approximately 150 cm of continuous cultural strata. It included leaf and seed fragments,

abundant wood and charcoal remains of ovens, and other cultural material. A number of coprolites consisting of densely matted organic matter, often with hair and small crushed bones, were recovered during excavation. Plant remains were recovered by hand picking during dry sieving (3 mm mesh) or as individual finds from different layers, particularly of leafy material. This deposit was excavated in two 50 cm x 100 cm sections (East Section 1 and East Section 2) at 5 cm spit intervals for the first 70 cm and at 10 cm spit intervals for the remainder of the deposit. Only East Section 1 (E1) is presented here.

Analysis

Seed and fruit analysis

Seed and fruit remains were identified on the basis of comparison with reference material held at the Department of Archaeology and Natural History, ANU, macrobotanical reference collection.

Archaeological wood charcoal analysis

Charcoals were described by comparison with a wood charcoal reference collection composed by M. Prebble from collections made on Rapa, and E. Dotte (unpublished data) from a number of collections from New Caledonia. The reference collection is representative of woody taxa regarded as fuel woods which were recorded by J.F.G. Stokes and E. Stokes between 1921 and 1922. The local plant names, botanical names and uses of these taxa are listed in Table 4.3. Some taxa were not included in the reference collection due to their rarity, namely *Metatrophis margaretae* (Urticaceae), known only from a single male specimen (Timothy Motley and Jean Yves Meyer pers. comm.), and *Santalum insulare* var. *margaretae* (Santalaceae). Taxa included in Stokes' list that are known as post-European contact introductions were not included in the reference collection (*Albizia lebbbeck*, *Citrus* spp., *Coffea arabica* and *Inga edulis*).

Microscopy was completed using an Olympus BH-2 epi-illumination incident compound microscope with 10x, 20x and 50x objectives. Given the low diversity of woody plant taxa on Rapa (<70) and the low number of preferred fuel woods (Table 4.3), only up to 50 charcoal pieces above 10 mm in widest dimension were randomly selected for analysis from each spit. As the basal spit (Spit 21) revealed little charcoal, additional charcoals were examined from Spit 20.

Palynological analysis

Two coprolite samples were chosen for palynological analyses to assess the potential for identifying dietary information about humans or dogs (*Canis familiaris*), the most likely producers (although dogs have not been recorded for pre-European Rapa). One cubic centimetre (cm³) volume sub-samples were taken from each coprolite. Pollen analysis of the coprolite samples was conducted using the standard preparation techniques. Microscopic charcoal fragments were also counted for each sample using the point count method. Pollen and spore identification was assisted by reference material collected in the field and regional reference collections held in the Department of Archaeology and Natural History, ANU.

Results

Archaeobotanical assemblages

The stratigraphic profile of the East Section 1 excavation is shown in Chapter 3. Associated weights for each type of plant material identified from each excavation spit are presented in stratigraphic order in Figure 4.2. The deposit can be divided into three units – beach sand with almost no cultural remains, and basal and upper cultural units. In the basal cultural unit of

Table 4.3. List of pre-European contact fuel woods used on Rapa, based on a botanical collection and ethnobotanical survey conducted by Margaret and John Stokes between 1920 and 1921. ANU reference wood charcoals are also listed.

Rapa vernacular	Stokes identification	Family: botanical name	Other uses apart from fuel wood	Reference charcoal
<i>Ai</i>	Tree (sandalwood)	Santalaceae: <i>Santalum insulare</i> var. <i>margaretae</i>	—	<i>Santalum neocaledonicum</i> *
<i>Aito</i>	Tree (<i>Weinmannia rapensis</i>)	Cunoniaceae: <i>Weinmannia rapensis</i>	Boat building	<i>Weinmannia rapensis</i>
<i>Aki</i>	Tree fern	Cyatheaceae: <i>Cyathea</i> spp.	Food, graters for oil	<i>Cyathea medularis</i>
<i>Anei</i>	Tree (Compositae)	Asteraceae: <i>Fitchia rapensis</i>	House posts	<i>Fitchia rapensis</i>
<i>Ariki</i>	Bush (<i>Homolanthus</i> sp.)	Euphorbiaceae: <i>Homolanthus stokesii</i> , <i>H. nutans</i>	—	—
<i>Gaio/Ngaio</i>	Tree (<i>Myoporum</i> sp.)	Myoporaceae: <i>Myoporum rapensis</i>	Boat building, medicinal	<i>Myoporum rapensis</i>
<i>Gatae/Ngatae/Patai</i>	Introduced tree (<i>Erythrina indica</i>) or possible <i>Inga edulis</i>	Fabaceae: <i>Erythrina variegata</i>	Canoes	<i>Erythrina variegata</i>
<i>Kaeka</i>	Tree (<i>Eugenia</i> sp.), probably introduced	Myrtaceae: <i>Syzygium malaccense</i>	Food	<i>Syzygium malaccense</i> *
<i>Kaema/Kaima</i>	Tree (<i>Glochidion longfieldiae</i>)	Euphorbiaceae: <i>Glochidion longfieldiae</i>	—	—
<i>Kai'ara</i>	Tree (<i>Pandanus</i> sp.) natives state 'indigenous' and 'introduced'	Pandanaceae: <i>Pandanus tectorius</i>	Food, medicinal, house thatch (recent), stringing, candles etc	<i>Pandanus tectorius</i>
<i>Kakatua</i>	Shrub (<i>Piper</i> spp.)	Piperaceae: <i>Macropiper</i> sp., <i>Peperomia</i> spp.	Medicinal	<i>Macropiper puberulum</i>
<i>Karaka</i>	Tree (Sapotaceae/ <i>Nesoluma polynesicum</i>)	Sapotaceae: <i>Nesoluma</i> spp.	—	<i>Pouteria cinerea</i>
<i>Koe</i>	Shrub/bamboo	Poaceae: <i>Schizostachyum glaucifolium</i>	—	—
<i>Kofe</i>	Tree	Araliaceae: <i>Meryta pauciflora</i>	—	<i>Schefflera</i> spp.
<i>Koi'ivai</i>	Shrub (Rubiaceae/ <i>Coprosma rapensis</i>)	Rubiaceae: <i>Coprosma</i> spp.	—	—
<i>Maiage</i>	Tree (<i>Sesbania</i> sp./ <i>Sophora tetraptera</i>)	Fabaceae: <i>Sophora tomentosa</i>	House posts, modern tool handles	<i>Sophora tomentosa</i> *
<i>Mairirakau</i>	Shrub (<i>Alyxia stellata</i>)	Apocynaceae: <i>Alyxia stellata</i>	—	<i>Alyxia stellata</i>
<i>Maroro</i>	Bush (<i>Metatrophis margaretae</i>)	Urticaceae: <i>Metatrophis margaretae</i>	—	—
<i>Mati</i>	Introduced tree (<i>Ficus tinctoria</i>)	Moraceae: <i>Ficus tinctoria</i>	Cordage	<i>Ficus tinctoria</i>
<i>Pakora/Nioi</i>	Shrub (<i>Plectronia kakenua</i> var. <i>obiculata</i> or possibly the tree <i>Cyclophyllum barbartum</i>)	Rubiaceae: <i>Plectronia</i> sp./ <i>Cyclophyllum barbartum</i>	—	<i>Cyclophyllum barbartum</i> *
<i>Po'oto</i>	Tree (<i>Eurya rapensis</i>)	Theaceae: <i>Eurya japonica</i> var. <i>Nitida</i>	—	<i>Eurya japonica</i> var. <i>nitida</i>
<i>Purau</i>	Introduced tree (<i>Hibiscus</i> sp.)	Malvaceae: <i>Hibiscus tiliaceus</i> syn <i>Talipariti tiliaceum</i>	House posts, canoes, paddles, boats, cordage, sandals, medicinal	<i>Hibiscus tiliaceus</i> syn. <i>Talipariti tiliaceum</i>
<i>Pua</i>	Tree (<i>Fagraea berteriana</i>)	Loganiaceae: <i>Fagraea berteriana</i>	Houses, canoes, medicinal, adornment	<i>Fagraea berteriana</i>
<i>Pūru/Purum</i>	Tree or shrub (<i>Sida rhombifolia</i>)	Euphorbiaceae: <i>Claoxylon collenettei</i> **	Perfume	—
<i>Rakau papa'a</i>	Introduced tree (<i>Albizia lebbek</i>)	Fabaceae: <i>Albizia lebbek</i>	—	—
<i>Raupata</i>	Tree (two forms of Compositae)	Asteraceae	—	—
<i>Rautea</i> ***	Tree	<i>Corokia collenettei</i> and <i>C. serrata</i>	—	—
<i>Tiari or tuitui</i>	Introduced tree (<i>Aleurites triloba</i>)	Euphorbiaceae: <i>Aleurites moluccana</i>	Canoes, lights, oil, medicinal	<i>Aleurites moluccana</i>
<i>Tireuei</i>	Tree (<i>Melastoma</i> sp./ <i>Celtis paniculata</i> var. <i>rapensis</i>)	Ulmaceae: <i>Celtis pacifica</i>	—	<i>Celtis pacifica</i> , <i>C. hypoleuca</i>

*From Emilie Dotte (unpublished reference collection); all other woods are from Rapa and other islands of the Austral archipelago.

Pūru* given for *Claoxylon collenettei* by Papaafatu (pers. comm.), Rapa.*Rautea/lautea* recorded by Tim Motley (unpublished data).

Figure 4.2. The material weights per excavated spit (the top 10 spits were excavated to a depth of 5 cm, with the lower seven spits to a depth of 10 cm) for the Tangarutu rockshelter from the E1 section. The deposit is divided into three units, a sterile basal sand layer underlying a charcoal-rich oven feature with oven stones within a sandy matrix (basal cultural unit). From Spit 7 (35-40 cm) to the surface, *Aleurites moluccana* and pieces of uncharred wood dominate a sandy matrix overlying a leafy layer at between 35 cm and 30 cm in depth (upper cultural unit). Introduced taxa labelled in **bold** text.

the deposit, from 140 cm to 35 cm in depth, we found fragments of charcoal associated with rounded basaltic stones indicative of an oven feature. Small amounts of *Aleurites moluccana* (10–35 g per spit; see Figure 4.2) were located in the upper part of this unit from 120 cm to 40 cm. The archaeological charcoal from 110–130 cm (spits 20 and 21) and 15–20 cm (Spit 4) is presented in Figure 4.3 and reveals distinct changes in fuel use. The basal spits are dominated by introduced cf. *Hibiscus tiliaceus* syn. *Talipariti tiliaceum* (Malvaceae) and cf. *Cordyline fruticosa*, but this changes in the uppermost spit to predominantly indigenous fuel and timber woods. The upper spit is dominated by the endemic species cf. *Myoporum rapensis* (Myoporaceae) and cf. *Fitchia rapensis* (Asteraceae), now restricted to small coastal populations and upland populations respectively (Figure 4.4 shows modern reference and archaeological charcoals).

Above 35 cm, a 5–10 cm thick layer of leafy remains distinguishes the upper unit, and upon sieving it produced pieces of *Hibiscus tiliaceus* syn. *Talipariti tiliaceum* cordage and fragments of plaited *Pandanus* and *Freycinetia* (Pandanaceae) baskets (Chapter 5). The amount of *A. moluccana* in each spit increased to weights between 70 g and 140 g per spit. Also in this unit the amount of unburnt wood remains increased, whereas the amount of charcoal and oven stones decreased. Fragments of the bottle gourd *Lagenaria siceraria* (Cucurbitaceae; Figure 4.4) and *Pandanus* keys (individual drupes of syncarpous fruits) were also identified within this unit. Other plant remains, including the abundant uncharred wood, have yet to be identified.

Two small, consolidated organic parcels located from the upper unit of E1, thought to be coprolite samples on the basis of the presence of hairs and crushed bone, were processed for pollen as a further means of identifying the presence of plant species in the Tangarutu deposit. Percentage pollen diagrams of these samples are presented in Figure 4.5. The uppermost sample found in Spit 1 (5 cm in depth) produced a range of pollen and spores, most known as wind-dispersed palynomorphs. The presence of *Freycinetia* and Euphorbiaceae pollen in these samples suggests that material from these plants may have been brought into the site. In the lower sample, found in Spit 2 (10 cm in depth), 75% of the palynomorphs identified are from *Freycinetia* (*F. arborea* or *F. rapensis*). Other pollen types probably introduced rather than wind blown into the site include Rubiaceae, cf. Liliaceae type and a high percentage of Cyperaceae pollen (ca. 18%). The high percentage of *Freycinetia* pollen is indicative of the probable introduction of these large flowers into the site, either brought in with leaves used for weaving and cordage, or with fruits for consumption.

Chronology

The archaeological material yielding the oldest radiocarbon ages at Tangarutu consisted of wood charcoal, unidentified to taxa at the time, immediately after excavation, when no means of identification was available (the formation of a Rapan identified wood collection being one of the objectives of the project, which took some time to reach fruition). Radiocarbon dates on charcoal samples, unidentified to taxa, indicate that the base of Tangarutu dates to at least AD 1300, with the upper deposits beginning about AD 1600 and extending up to immediately before European arrival (Chapter 11).

Later, three radiocarbon ages were taken from fruit and nut remains from East Section 1 (see Table 4.4), one from *Aleurites moluccana* endocarp, one from *Lagenaria siceraria* pericarp and one from a *Pandanus* cf. *tectorius* key. Unlike unidentified charcoal, the inbuilt age of fruit and nut remains is expected to be merely a year or so. Radiocarbon dates from *A. moluccana* endocarp provide the most reliable chronology, because of their inherently low inbuilt age and their availability through almost all of the stratigraphic units. The earliest date from *A. moluccana* endocarp has an age range of AD 1049–1628 (ANU 12102), which brackets the age range

Figure 4.3. The archaeobotanical charcoal count data (by tentative family and species determinations) for the Tangarutu rockshelter from three spits of the E1 section. The basal spits (E1 spits 21 and 20) are from the base of a charcoal-rich oven feature with oven stones within a sandy matrix and represent the (basal cultural unit of the E1 section). The upper spit (E1 Spit 4) is from a leaf (*Freyinetia* and *Pandanus*), candlenut (*Aleurites moluccana* endocarp) charcoal and wood-rich unit. Taxa are arranged firstly by first appearance, then by use (e.g. fibre etc). Introduced taxa labelled in **bold** text.

Figure 4.4. Digital images of modern reference and archaeological charcoals, *Fitchia rapensis*, *Myoporum rapensis*, *Pandanus* and *Aleurites moluccana* endocarp.

Figure 4.5. Percentage diagram of pollen and spore assemblages from two consolidated organic samples from the East Section 1 excavation (spits 1 and 2), Tangarutu rockshelter. Taxa with >5% of total palynomorph sum are presented as bars; samples with proportions <5% are presented as triangle symbols; and total palynomorph counts. Introduced taxa labelled in **bold** text.

Table 4.4. List of radiocarbon dates obtained from the Tangarutu rockshelter East section Square E1 and for comparison E2.

Sample/depth (cm)	Material dated	Weight (g)/amount in spit (g)	Lab code	C14 age (uncal.)	2 s cal. AD
E1 Spit 4/20–25	<i>Lagenaria siceraria</i> pericarp	<2/6	UCI 14763*	320+/-15	1510–1648
E1 Spit 4/20–25	<i>Aleurites moluccana</i> endocarp	12/100	ANU 12101**	410+/-60	1442–1638
E1 Spit 11/55–60	<i>Aleurites moluccana</i> endocarp	5/5	UCI 14772*	345+/-20	1501–1642
E2 Spit 18/100–110	<i>Aleurites moluccana</i> endocarp	12/n.d.	ANU 12100	380+/-60	1449–1648
E1 Spit 19/110–120	<i>Pandanus</i> cf. <i>tectorius</i> key	2.55/20	ANU 12102*	660+/-150	1049–1628
E2 Spit 23–25/130–150	Unidentified charcoal	10/10	ANU 11848**	710+/-70	1228–1407
East Section T1/150	Unidentified charcoal	<10/20	UCI 14769**	905+/-20	1152–1222

Presented are the sample depths, radiocarbon laboratory (UCI=University of California Irvine; ANU=The Australian National University), material dated, weight of material dated/the amount of material found in spit, laboratory sample codes, uncalibrated determinations (*AMS, **conventional) and calibrated ages to 2s. Dates were calibrated using the program Calib 6.0. (Stuiver et al. 2005) using the Southern Hemisphere Calibration Curve (McCormac et al. 2004).

from a piece of unidentified charcoal from the lowest unit of the excavation, AD 1128–1407 (ANU 11848). Unfortunately, the basal *Pandanus* key produced a large uncalibrated error due to inadequate carbon concentration.

Archaeobotanical research in the Austral and Cook islands

Tangarutu rockshelter is notable for having well-preserved plant remains found in very high concentrations that are comparable to other excavations from tropical and subtropical Remote Oceania (e.g. Kirch et al. 1995; Weisler 1995; Burney et al. 2001; Allen and Wallace 2007). Aside from charcoal, the recovery of identified plant remains from archaeological sites in the Cook and Austral islands has been minimal. In tables 4.5 and 4.6, indigenous and introduced plant remains excavated from Tangarutu are compared with those from excavations at Ureia, Aitutaki (Allen and Wallace 2007), and Tangatatau, Mangaia (Kirch et al. 1995) in the Cook Islands. Wood charcoal (unidentified to species) and endocarps of *Aleurites moluccana* are the most common archaeobotanical remains found at each site.

Indigenous plant remains

Charred and uncharred keys and some wood charcoals of *Pandanus* cf. *tectorius* (Figure 4.4) represent the indigenous food plant identified at Tangarutu, Tangatatau and Ureia (Table 4.3). Apart from *Pandanus*, *Hibiscus tiliaceus* syn. *Talipariti tiliaceum* is the only wood found at Ureia and Tangarutu, where it was probably used for both fibre and fuel (Table 4.3). All the remaining taxa identified at Tangarutu are, from the ethnobotanical notes of Stokes (n.d.), primarily fuel woods and mostly endemics, including species of *Myoporum*, *Fitchia* and *Hernandia* (Figure 4.3).

Pandanus tectorius Parkinson

It is possible that remains of *Pandanus* represent indigenous species other than *P. tectorius*, but this cannot be established from the macrobotanical remains alone. Whistler (1991) has questioned the status of *Pandanus tectorius* as an introduced species to Remote Oceania. He suggested that *P. tectorius* of both Tonga and Samoa is represented by both indigenous and introduced populations, but queried the indigenous status of *Pandanus tectorius* in the Cook, Austral, Society, Marquesas and Hawaiian islands. *Pandanus* pollen has been identified from pre-human Holocene sediments on Rapa, Rimatara (Prebble and Wilmshurst 2009) and Mangaia.

Table 4.5. Comparison of indigenous plants identified from Ureia, Aitutaki (Allen and Wallace 2007), Tangatatau, Mangaia (Kirch et al. 1995), and Tangarutu archaeobotanical deposits.

Indigenous taxa	Ureia	Tangatatau	Tangarutu
<i>Argusia argentea</i> syn. <i>Tournefortia</i> (Boraginaceae) wood	+	?	n
<i>Caesalpinia major</i> (Fabaceae) seed	?	+	n
<i>Freycinetia</i> sp. (Pandaceae) leaf	n	n	+leaf, pollen
<i>Guettarda speciosa</i> (Rubiaceae) wood	+	?	n
<i>Hernandia</i> sp. (Hernandiaceae) seed		+	-
<i>Hibiscus</i> spp. cf. <i>tiliaceus</i> ¹ (Malvaceae) fibre, bark	+	?	+ fibre, charcoal?
<i>Pandanus</i> sp. (Pandaceae) leaf, keys	+keys	+keys, leaf	+keys, leaf, charcoal
<i>Pemphis acidula</i> (Lythraceae) wood	+	?	n
<i>Pouteria grayana</i> syn. <i>Plachonella</i> (Sapotaceae) seed	+	?	n
Palmae (Arecaceae) wood	+	?	?
<i>Terminalia</i> (Combretaceae) wood	+	?	n
<i>Thespesia populnea</i> ² (Malvaceae) wood	+	?	n

+ = identified in the deposit; ? = found on the island but has yet to be identified in the deposit; n = is currently not located on the island.

1 The indigenous or exotic status of *Hibiscus* cf. *tiliaceus* syn. *Talipariti tiliaceum* on the Cook and Austral islands is uncertain (Whistler 1991; Florence 2004).

2 The indigenous status of *Thespesia populnea* on Rapa is uncertain (Florence 2004).

Table 4.6. Comparison of introduced plants identified from Ureia, Aitutaki (Allen and Wallace 2007), Tangatatau, Mangaia (Kirch et al. 1995), and Tangarutu archaeobotanical deposits.

Introduced taxa	Ureia	Tangatatau	Tangarutu
<i>Aleurites moluccana</i> (Euphorbiaceae) endocarp	+	+	+endocarp (Figure 4.4)
<i>Artocarpus altilis</i> (Moraceae) wood, fruit	+	?	?
<i>Calophyllum inophyllum</i> (Clusiaceae) wood	+	?	n
<i>Cocos nucifera</i> ¹ (Arecaceae) endocarp, husk, leaf, bracts, wood charcoal	+	+	?
<i>Colocasia esculenta</i> (Araceae) corm	?	+	+
<i>Cordia subcordata</i> ² (Boraginaceae) seed	+	?	n
<i>Cordyline fruticosa</i> (Laxmanniaceae) stem, leaf, charcoal	+	+	+leaf, charcoal?
<i>Cyrtosperma merkusii</i> (Araceae) corm	?	+	n
<i>Ipomoea batatas</i> (Convolvulaceae)	?	+	?
<i>Inocarpus fagifera</i> (Fabaceae) wood charcoal	?	+	n
<i>Lagenaria siceraria</i> (Cucurbitaceae) pericarp	?	+	+
<i>Musa</i> sp. (Musaceae) leaf	?	+	?
<i>Saccharum officinarum</i> (Poaceae) stem	?	+	?
<i>Schizostachyum glaucophyllum</i> (Poaceae) stem	?	+	?

+ = identified in the deposit; ? = found on the island but has yet to be identified in the deposit; n = is not located on the island and is unlikely to be found in the deposit.

1 Considered to be indigenous to the Cook and Austral islands, except on Rapa but has been repeatedly introduced by Polynesians, contributing to the expansion of its natural range on islands (Athens 1997).

2 Considered to be introduced to the Cook Islands (Bill Sykes pers. comm. 2007).

Ellison (1994) establishes the indigenous status of *Pandanus* on these islands and presumably the other Cook and Austral islands. Further support for the indigenous status of *Pandanus* in Remote Oceania comes from an unpublished report (in Athens 1997) of Pleistocene macrofossil remains of *Pandanus* on the Hawaiian Islands, where it has a minimum age of 500,000 years.

The botanist Archibald Menzies (Shineberg 1986) on the initial European visit to Rapa in 1791 mentioned *Dracaena* leaves, which probably refers to *Pandanus*, in reference to a girdle suspended around the waists of the local Polynesians. Indications from the pollen records from Rapa suggest that these trees were probably common at first European contact. Whether the *Pandanus* population had natural as well as cultural origins is unknown.

Pandanus is a dioecious genus with extreme morphological diversity that can be influenced by cultivation practices. This has resulted in a number of inconsistent taxonomic determinations of members of this genus (see Stone 1976, 1988; and St. John 1976, 1979). From his Pacific Island plant collections from the 1920s, St. John (Fosberg and St. John 1934) identified 13 endemic species of *Pandanus* on Rapa alone. Most of these species have subsequently been grouped into *Pandanus tectorius*, and one other species has yet to be described (Tim Motley and Jacques Florence pers. comm. 2004). The morphological diversity in the genus *Pandanus* that St. John identified on Rapa may be a result of genetic or environmental processes, but may also reflect the introduction of cultivated varieties by Polynesians both pre- and post-European contact.

The ethnobotanical importance of *Pandanus* on Rapa is confusing. One of Stokes' (n.d. Box 7.1) main informants, Teraau, noted the indigenous status of *kai'aral'fara* (*Pandanus*) and *magu* (*Freycinetia* spp.), but asserted that there was no mat-making, which is unlikely and contradicted by abundant ethnographic evidence (Chapter 2) and some archaeological remains (Chapter 5).

Hibiscus L. and *Thespesia populnea* (L.) Solander ex Correa

The lack of early ethnographic evidence for fibre production involving the Polynesian *miro* (*Thespesia populnea*) and *purau* (*Hibiscus* spp.) is intriguing. The indigenous status of *T. populnea* on Rapa is uncertain and it is more often considered a Polynesian introduction (Florence 2004). The few specimens that now remain on Rapa appear to survive only by cultivation, but the overwhelming effect of feral grazing animals precludes any reasonable test of whether they could survive otherwise. The most reliable and earliest radiocarbon age obtained directly from archaeobotanical material in the Cook and Austral islands material comes from cf. *T. populnea* wood at the Ureia site, Aitutaki, dated to AD 1240–1405 (Wk-18408; Allen and Wallace 2007). No pre-human remains of *T. populnea*, pollen, wood or charcoals have been identified from the Cook or Austral islands. The status of *Hibiscus* is more confusing given that Florence (2004) has described two species (*H. australensis* and *H. tiliaceus*) and one subspecies (*H. tiliaceus* subsp. *tiliaceus*). Like *Thespesia*, no pre-human remains of *Hibiscus* have been identified from the Cook or Austral islands, and for this reason these genera should be considered Polynesian introductions to Rapa and perhaps to the most southern islands of the Cook and Austral islands.

Introduced plants

Introduced taxa make up the greatest proportion of plant remains identified from the base of the main E1 sequence. The basal cultural unit outlined is indicative of an oven and an associated midden, initially used 1300–1400 AD. The dominance of remains from tropical and introduced fibre plants (*Cordyline fruticosa*, *Hibiscus tiliaceus* syn. *Talipariti tiliaceum* and *Thespesia populnea* and candlenut *Aleurites moluccana*) suggests that the early economic activity on this sub-tropical island centred on processing plants imported from the tropics. Fibre plants used for cordage and

basketry are essential components of Polynesian material culture for clothing, binding for boats and weapons, fishing equipment, lashing for building construction and numerous other tasks. Apart from *Pandanus tectorius* and *Freycinetia* spp., there are few indigenous plants that could provide fibre essential for sustaining Polynesian material culture.

In his ethnography of Rapa, Stokes (n.d. box 7.1) doubted the claims from his informants that all the main fibre plants aside from *Pandanus* and *Freycinetia* – *purau*, *orā*, *aute* and *mati* (See Table 4.3) – are indigenous. Even if these plants were not indigenous to Rapa, as on other islands, they remain prime candidates for early introduction given their economic importance to Polynesians. Almost all the plants identified in the assemblage, indigenous or introduced, are now rare or absent from the vicinity of the rockshelter and from Anarua Bay.

Aleurites moluccana (L.) Willdenow (Euphorbiaceae)

Of the introduced plant taxa represented in rockshelter deposits on Rapa, *A. moluccana* endocarps make up a large proportion of the archaeobotanical material identified, especially in the case of the Tangarutu excavation. Kirch et al. (1995) did not present data on the amount of endocarp identified from the Tangatatau excavation, but suggest it is abundant. In the Tangatatau and Tangarutu excavations, *A. moluccana* endocarps are represented throughout each deposit. Endocarps of *A. moluccana* are only represented in the basal Zone E deposit of Ureia (Allen and Wallace 2007).

In Remote Oceania, endocarps of *A. moluccana* have been identified from several archaeological sites in the Hawaiian Islands (e.g. Māhā'ulepū, Kaua'i, Burney et al. 2001; Mauna Kea, Hawai'i, Allen 1981), Mangareva (Weisler 1995; Conte and Kirch 2005), Henderson Island (Weisler 1995), Pitcairn Island (Weisler 1996), and more recently, New Caledonia (Emilie Dotte pers. comm.). Athens and Ward (1997) located *A. moluccana* endocarp and wood from Maunawili (Core 1) at 86–94 cm below the swamp surface, and provided an interpolated age from a charcoal date of 688–655 BP (Beta-5490). The pre-European contact distribution and introduction of *A. moluccana* may have extended as far as Raoul Island in the Kermadec Group (New Zealand), although this could represent a historic introduction (Sykes and West 1996).

Despite the abundance of preserved *A. moluccana* endocarps in the archaeological record from Rapa, this tree was not listed in any early accounts of the island until Jacques Moerenhout (1837) visited in 1834. Stokes (n.d.) noted the use of *A. moluccana* wood for construction of canoes and nuts for lighting. From visits to the island between the 1920s and 1930s, both Stokes (n.d.) and Fosberg (in Mueller-Dombois and Fosberg 1998:403 respectively) considered *A. moluccana* to be a major component of moist forests on Rapa. Despite its importance only 50 years ago, few trees currently exist on the island. Some trees are located precariously on the margins of coastal plains or in a few localities around the major settlements of Ha'urei and Area, where the nuts provide fodder for pigs.

Fosberg (1991:18) has questioned whether the tree has been introduced to Remote Oceania, as the nuts of this tree are commonly found as beach-drift throughout the Pacific:

The theory that it is an introduction is favoured and, indeed, suggested by the unlikelihood of its having climbed the steep mountain slopes [of the Hawaiian Islands] up to its present habitat without human assistance. If it was brought by humans and carried up the hills by them, it spread to dominate a whole zone on many islands, forming pure stands and shading out almost all other plants, and made an important change. On some islands kukui forest occupies roughly the rainfall belt (between 1500 and 2250 mm of rainfall a year), with tongues of this forest running some distance down moist ravines to lower elevations. The landscape was modified conspicuously by the introduction of *A. moluccana*, whether by the hand of humans or dispersed naturally.

Lagenaria siceraria (Mol.) Standlicher (Cucurbitaceae)

The most recent analyses of the distribution and ethnobotany of *L. siceraria* in Remote Oceania come from Decker-Walters et al. (2001), Smith (2005) and Clarke et al. (2006). Archaeological remains suggest that the domestication of *L. siceraria* may have been independently developed in the Americas by 7000 BC (Smith 2005), South East Asia between 8000 and 4000 BC, and Africa between 3000 and 2000 BC (Heiser 1979). Bellwood (1997) has observed that *L. siceraria* was present in Taiwan at the time of the Austronesian expansion out of this area about 3000 BC, and Decker-Walters et al. (2001) assessed the diversity of landraces of *L. siceraria* from each of the above areas, including New Guinea, using random amplified polymorphic DNA. They found that the landraces of New Guinea could be distinguished from American specimens.

Based on linguistic and limited archaeobotanical evidence, Green (2000, following Ross 1996) suggests that *L. siceraria* was absent from Near Oceania at the time the closest islands in Remote Oceania were first settled around 1500 BC to 1000 BC. Green supports this claim by noting the absence of *L. siceraria* in the rich archaeobotanical assemblages from the waterlogged sites at Dongan in the lower Ramu, Papua New Guinea (Swadling et al. 1991). Green (2000) also cites the earliest interpolated date in Near Oceania for *L. siceraria* at 1230–1960 BC (ANU-43) from the Manton site at Warrawau, upper Wahgi Valley, Central Highlands, Papua New Guinea (Golson et al. 1967). Golson (2002), however, has now revised the Manton gourd rind determination, and has tentatively assigned it to the wax gourd *Benincasa hispida* on the basis of recent finds of this rind in an archaeological site at Kana (dated to 1005 BC to 20 AD; ANU-9487), at a slightly higher altitude to Manton, also in the Wahgi Valley.

Fragments of *L. siceraria* pericarp have been identified from a number of archaeological sites in the Hawaiian Islands, including the Ewa Plain and Kawainui Valley (Allen-Wheeler 1981) on O'ahu, as well as Maha'ulepu Caves, Kaua'i (Burney et al. 2001). Horrocks et al. (2000) identified *L. siceraria* pollen in an exposed section of two archaeological stone garden mounds at Pouerua, Northland, New Zealand. *L. siceraria* has an entomophilous flowering biology in which pollen is only deposited in the direct vicinity of the parent plant. This effect would be intensified given the low stature of *L. siceraria*. Horrocks et al. (2002) have identified *L. siceraria* pollen from dog or human coprolites of around AD 1300–1600 (NZA-12591) buried in a beach dune on Great Barrier Island in the Hauraki Gulf, New Zealand. These data suggest direct consumption of flowers, but might also reflect consumption of residues on young *L. siceraria*, or even inadvertent ingestion during hand pollination (Horrocks 2004).

The introduction of *L. siceraria* on Rapa contradicts Green's (2005) argument that *L. siceraria* was brought with *I. batatas* after European contact. The 16th century age for bottle gourd on Rapa suggests it was introduced pre-contact. However, the lack of evidence for *I. batatas* from any excavation on Rapa and the late appearance of *L. siceraria* in the Tangarutu E1 sequence imply that neither plant was introduced during initial Polynesian colonisation.

Further support for the Polynesian introduction of *L. siceraria* to Rapa comes from the description of 'dried pumpkin' by Faddei Von Bellingshausen, although this might otherwise describe *Ipomoea batatas* tubers (Barratt 1988). Ethnographic information collected by Stokes (n.d.) and others on Rapa suggests that *L. siceraria* was one of the few actively cultivated plants on Rapa in the early 1900s, other than *Colocasia esculenta*, *Dioscorea* spp. and *Ipomoea batatas*. Stokes (n.d. Group 2 Box 7.1) found that 'Seeds of the gourd (koali) are set in the ground with little preparation, and the plants are left to look after themselves'. Fosberg and St. John (1934) only identified *L. siceraria* cultivations at Akatanui Bay, a site now largely abandoned for cultivation.

Conclusion

The Tangarutu assemblage is exceptional in both the abundance and preservation quality of plant materials. *Aleurites moluccana* endocarps, *Lagenaria siceraria* pericarp (bottle-gourd) and leaf fibres of *Pandanus* spp. and *Freycinetia* spp. are well preserved. Archaeological charcoals in the basal part of this deposit are derived primarily from introduced economic taxa, including cf. *Hibiscus tiliaceus* syn. *Talipariti tiliaceum*, cf. *Thespesia populnea* and cf. *Cordyline fruticosa*, suggesting that the establishment of introduced plants was rapid and an important part of island colonisation strategy. Radiocarbon ages obtained from fruit and seed remains excavated from the Tangarutu sequence are discussed in reference to the settlement sequence of Rapa. The earliest ages obtained from *A. moluccana* endocarp and *Cordyline* wood, produced from introduced and cultivated trees, are slightly later than the Bayesian-modelled age estimate for initial colonisation of the island.

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