Archaeobotany of fruit seed processing in a monsoon savanna environment: evidence from the Keep River region, Northern Territory, Australia

Jennifer Atchison\(^a\), Lesley Head\(^a,\)*, Richard Fullagar\(^b\)

\(^a\)GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong 2522, Australia
\(^b\)Department of Prehistory and Historic Archaeology, University of Sydney, 2000, Australia

Received 15 April 2003; received in revised form 11 March 2004

Abstract

We analyse archaeobotanical remains from three excavated rockshelter sites, Jinmium, Granilpi and Punipunil, in the Keep River region, northwestern Australia. The record is dominated by burnt fragmented seed remains from the fruit trees *Persoonia falcata* and *Buchanania obovata*, consistent with ethnographic records of whole fruits being pounded into pastes and cakes at the beginning of the summer wet season. Surface seed samples of non-cultural origin are mostly whole and unburnt, and contain higher proportions of grass seeds. Sustained processing of fruit seeds is first visible in the archaeological record about 3500 years ago. Spatial and temporal variation in its intensity is evident since that time until it declines following European colonisation. The decline does not represent total site abandonment, but a reorientation of activities following the ecological and social changes that came with pastoralism. The former included the local decline of *P. falcata* with more intense fire regimes.

© 2004 Elsevier Ltd. All rights reserved.

Keywords: *Persoonia falcata*; *Buchanania obovata*; Ethnobotany; Holocene

1. Introduction

Hunter–gatherer interactions with plants have long been an important ingredient of debates surrounding agricultural origins [12]. As Hastorf [13] has argued, there are now many archaeological examples of plant cultivation and use either preceding, or independent of, the morphological changes in plants usually involved in strict definitions of agriculture. Many plants were actively tended, moved around and actively used for thousands of years without visible morphological change ([13]: p. 773). This significant problem of archaeological visibility continues to constrain understanding of the range of ways people interacted with their environments during the Holocene.

The focus on morphological change has involved a focus on grains and starchy staples (e.g. [19]) and their role in the reproduction of sedentism, surplus and hierarchy. However, Hastorf ([13]: p. 773, after Farrington and Urry [9]) argues that the earliest propagated plants included rather the ‘medicinal, industrial, spicy, hallucinatory or merely exotic’. In this paper we use the example of fruits and fruit processing. Although their archaeological preservation is somewhat fortuitous (cf. [4]), these remains illustrate a broader social context of plant use in which preservation, storage, seasonality and gender are all important variables.
In her overview Hastorf draws most examples from South America, but the issues are salient in a variety of environmental contexts. Despite an extensive ethno-botanical literature relevant to Aboriginal use and processing of plant foods in northern Australia, the archaeobotanical visibility of these activities remains limited. Aboriginal people maintain detailed knowledge of – and in many cases practise – the management and utilisation of carbohydrate staples, seasonally abundant fruits, grass seeds and potentially toxic plant foods such as cycads (e.g. [8,16,18,21,28,31]).

The seasonal tropics offer particular challenges to archaeological preservation. Microscopic material preservation sites, notably pollen, are restricted to the north east of the continent, and most sites with archaeobotanical remains are restricted to the Holocene [5,10,17,20,25,30]. Consequently any identifiable material recovered in the region is of significance. On a continental scale the picture of Australian Aboriginal plant interactions provided by archaeobotany is at best fragmentary, containing poor quality preserved material in mostly localised recorded sites. A notable exception is the Carpenter’s Gap site in the western Kimberley, dated to about 40,000 BP [23,24]. McConnell and O’Connor examined extensive macro-botanical remains, inferring continued Aboriginal occupation and utilisation of a wide variety of species in the southwestern Kimberley during the last glacial maximum.

In this paper we analyse new material from archaeobotanical remains at three sites across a region of the eastern Kimberleys: Jinmium, Granilpi, and Punipunil excavated in the Keep River, northwest Northern Territory (Fig. 1). This study is part of a broader project examining long term relationships between Aboriginal people and their environment in the region. Our specific aims here are to:

- distinguish between the cultural and non-cultural components of the archaeobotanical record via morphology and species assemblage,
- examine the chronology and taphonomy of the cultural plant remains,
- by comparing archaeobotanical and ethnobotanical evidence, infer patterns of Aboriginal plant utilisation and environmental interaction both prior to and immediately after European contact.

We will argue that plant visibility in this archaeological record is a direct result of people processing the fruit, adding complexity to questions of resource abundance and availability. We will also demonstrate that the plant record contributes significant information to broader understandings of hunter-gatherer response to change by adding detail to questions about seasonality, resource manipulation and burning.

Fig. 1. Keep River study area, northwestern Northern Territory, Australia.

2. Study area

The areal focus of the study is the lower Keep River catchment in the northwest corner of the Northern Territory (Fig. 1). The region has a warm, dry monsoonal climate with a distinct wet season between December and April, and annual rainfall of 750–900 mm. Most important land systems in the area are estuarine deltaic plains, open woodlands over tall grass sandy plains, and rugged sandstone and conglomerate hills with a series of more isolated outliers. Jinmium, Granilpi and Punipunil are all examples of the latter. Aboriginal groups with attachments to this area include Gajerrong, Miriuwong, Jamanjung and Murinpatha people.

The region is dominated by a large sandy plain, predominantly vegetated by savanna woodland. The upper stratum of this savanna is mostly *Eucalyptus* with *Eucalyptus tetradonta* and *Eucalyptus miniata* being dominant. Other common genera include *Acacia*, *Terminalia* and *Gardenia*. The understorey is mostly grass with *Sehima*, *Chrysopogon*, *Themeda*, *Heterpogan*, *Sorghum* and *Plectrachne* being common [29]. Within the savanna woodlands a number of trees that produce edible fruits are also present. We focus here on *Buchanania obovata* (Murinpatha name: kilen, common names: bush mango, wild mango, green plum) and *Persoonia falcata* (Murinpatha name: kathan, common name: wild pear). *B. obovata* trees are today scattered widely throughout the savanna, but also occur in
clusters that offer particularly abundant sources of fruit. *P. falcata* now has a much more restricted distribution in the study area, for reasons discussed later in the paper.

### 3. Methods

Of the dozen excavations undertaken for the project, those with significant quantities of archaeobotanical remains including consistent preservation at depth were chosen for detailed analysis. Some excavated pits contained very small volumes of poorly preserved material that were not useful for identification and analysis. Recovered material from the seven suitable 1 × 1 m pits (four at Jinmium, one at Granilpi and two at Punipunil) are discussed here. Excavations followed natural stratigraphic changes with a maximum spit depth of 15 cm. All excavated material was dry sieved in the field through 2–4 mm and 0.4 mm sieves, prior to being transported back to the laboratory. Bulk samples of the <2 mm sediment were also collected.

An assessment of the modern seed assemblage close to each archaeological site can provide a useful picture of contemporary seed distribution. This analogue enables an examination of the present day vegetation, contemporary dispersal processes, and resulting modern assemblages, as well as some insight into what differences there might be between cultural and non-cultural assemblages. Seed distribution is influenced by a range of dispersal factors including, distance from parent plant, wind, rolling, and animal action such as birds, bats etc. Nine modern samples were collected at Jinmium and seven at Marralam over a 2 ha plot containing the excavated pits. This included sampling under the entire range of parent tree species present at each site. An area of soil and surface litter approximately 20 cm × 30 cm (the size of a spade) and 10 cm deep was collected in each case. For consistency with the excavation samples the surface samples were also sieved back in the laboratory using the same sieve sizes (4 mm and 2 mm).

All samples were extremely dry and fragile, with high proportions of burnt and carbonised material. Experiments with wet sieving [3] caused considerable damage to the remains so only hand sorting was undertaken. Material from both surface and archaeological samples was sorted in two size fractions, >4 mm and 2–4 mm. A pilot study of seed recovery from the <2 mm fraction of the surface samples indicated that the time and expense of this procedure was not warranted by the additional information obtained. In 15 of the 16 samples more species were recovered from the >2 mm than <2 mm fractions, so the smaller fraction of the archaeological sediments was not analysed.

The lack of archaeobotanical keys in Australia [6] means that reference collections need to be developed for individual projects. A collection of representative botanical material prepared by Allen [2] and additional material obtained by JA were sent to the Parks and Wildlife Commission of the Northern Territory herbarium for identification. Further specimens (predominantly grasses) were sent to the N.S.W. Department of Agriculture Seeds Laboratory, the Australian National Herbarium and the Queensland herbarium of the Brisbane Botanic Gardens. Identified and unidentified seeds were counted, photographed and examined for morphological evidence of gnawing or other use–wear features and compared with recorded ethnographic information for evidence of processing. Through these methods a significant proportion of the collection was identifiable, however quantities of unidentified specimens are also recorded in the results. The size of the reference collection is small and constrained as wet season access to the sites was not possible. This limited the flowering and fruiting bodies that could be collected from each species, however the NT government collections are extensive and were utilised with the assistance of trained botanists.

*B. obovata* seed fragments can be distinguished from *P. falcata* seed fragments on the basis of surface patterning and shape. *B. obovata* seeds showed some surface patterning on the outer surface and in most cases had fractured along the natural fracture plane (Fig. 2a,b). *P. falcata* seeds and seed fragments had a distinct lack of surface patterning and the seeds had no...
natural fracture plane. Seed fragments of *P. falcata* were generally more angular than those of *B. obovata* (Fig. 2c,d).

AMS 14C dating was used here to examine directly the age of seed fragments (*P. falcata*) recovered from the three archaeological deposits, for comparison with other 14C, TL and OSL dates. As well preserved *P. falcata* seeds were found consistently throughout the profiles of each of the deposits, dating was focused on this species.

4. Results

4.1. Surface seed assemblages

The common feature of all the surface assemblages at Jinmium and Marralam is the widespread occurrence of grass seeds, notably *Heteropogan contortus* and *Panicum* sp. (Table 1). Fruit seeds are locally abundant close to parent trees, for example under *Erythroxylum ellipticum*, *B. obovata* and *Terminalia latipes* trees. Most recovered material was unburnt. Samples collected from Marralam had the highest proportions of burnt to non-burnt seeds, no doubt because the site had been burnt fairly recently prior to sampling.

4.2. Jinmium

The prominent stacks and boulders called ‘Jinnieum’ are located at the northwestern edge of several hectares of outcropping sandstone with rock art and archaeological deposits in at least eight rockshelters. The C1/IV pit is located 15 m west of the main rock shelter. The seed assemblage in this pit is wholly confined to the upper unit, i.e. the top 40 cm and was more similar to the surface grab samples than any of the other excavated deposits. A range of grasses was found, mostly within the top 10 cm. *Panicum* sp., *Mimosaceae*, *Lotus* sp. and *P. falcata* seeds were found below 30 cm, however, these were all recovered in very low densities. A small peak in burnt seeds is recorded in C1/IV, comprised wholly of *P. falcata* seeds. While this pit contains abundant other archaeological material, e.g. stone artefacts, it has less culturally deposited plant material. This could be either because processing was concentrated closer to the shelter, or because the more open context of C1/IV on the sand plain has mitigated against preservation of plant material.

The maximum depth of each of the four Jinmium excavation pits (C1/I–IV) was approximately 200 cm with cultural material found to a depth of 150 cm. Each pit was predominantly comprised of loose partially sorted sand with rubble increasing in density towards the base. Seven stratigraphic Units have been defined and are summarised in detail in Fullagar et al. [11]. Archaeological materials included pounding stones, cores, stone points and flaked stone, as well as other materials of cultural origin including ochre, charcoal and various types of bone.

In the upper Units (6 and 7) of pits C1/I (Fig. 3), C1/II and C1/III (Fig. 4), the >4 mm fraction contains a diversity of taxa including grasses (e.g. *H. contortus*), and fruit seeds such as *B. obovata*, *P. falcata*, *T. latipes*, and *Vitex glabrata*. In all cases the fruit seeds are unburnt. Some whole, i.e. intact, but burnt *B. obovata* and *P. falcata* seeds were recovered from Unit 3 of C1/I. Seed dates are shown in these diagrams and summarised in Table 2.

The species assemblage of the upper Units of the 2–4 mm fractions (Figs. 5 and 6) is fairly similar with the addition of smaller seed species such as *Glycine* sp., *Setaria apiculata* and *Yakirra majuscula*. The lower Units of the 2–4 mm fractions are however markedly different to the larger fractions. Most notable are the high densities of *P. falcata* and some *B. obovata* seed fragments, particularly in C1/III. In pit C1/I the density of both of these species peak in Unit 3, while in pits C1/II and C1/III these seed fragments peak in Unit 4. All of the seed fragments from these two species below unit 5 were burnt.

4.3. Granilpi

The Granilpi excavation site is within a boulder cluster on the western side of an extensive sandstone outcrop displaying abundant rock art [32]. The rock-shelter is composed of two large leaning boulders forming a shaded tunnel. The maximum depth reached in the G1 pit was approximately 150 cm with cultural material found down to this depth. One major stratigraphic break was observed in the G1 profile between dark organic sediment with charcoal, at 60–70 cm, which overlays an orange sand. Archaeological material includes high densities of flaked quartz, quartzite and fine grated stone as well as a number of stone points, some bone, shell and ochre.

The top few spits (Unit 3 and top half of Unit 2) (Figs. 7, 8) of both size fractions contain a diversity of fruit tree seeds and seed fragments, including *B. obovata*, *Owenia vernicosa*, *P. falcata*, *Pavetta brownii*, *T. latipes* and *V. glabrata*. *H. contortus* and unidentified seeds make up the remainder of the upper assemblage. Similar to Jinmium, the two species *B. obovata* and *P. falcata* form the dominant component of the lower half of Unit 2. *B. obovata* peaks in spit 8 (32.6–37.5 cm) and *P. falcata* in spit 11 (48.75–54.1 cm). Almost all of the seeds recovered from below 30 cm depth were burnt.

4.4. Punipunil

Punipunil is a shallow rockshelter up to 10 m from dripline to rear rockwall lying along the base of a steep
Table 1
Numbers of whole, fragmented, burnt and unburnt seeds from the surface sampling at Jinmium and Marralam

<table>
<thead>
<tr>
<th>Taxa</th>
<th>J1</th>
<th>J2</th>
<th>J3</th>
<th>J4</th>
<th>J5</th>
<th>J6</th>
<th>J7</th>
<th>J8</th>
<th>J9</th>
<th>M10</th>
<th>M11</th>
<th>M12</th>
<th>M13</th>
<th>M14</th>
<th>M15</th>
<th>M16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia sp.</td>
<td>w.6</td>
<td>w.4</td>
<td>w.1</td>
<td>w.1</td>
<td>w.1</td>
<td>w.1</td>
<td>f.1</td>
<td>w.2</td>
<td>w.35</td>
<td>f.3</td>
<td>ub</td>
<td>w.2</td>
<td>w.35</td>
<td>f.3</td>
<td>ub</td>
<td>f.25</td>
</tr>
<tr>
<td>Allotropis semialata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alysicarpus sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buchanania obovata</td>
<td>f.1</td>
<td>b</td>
<td>f.5</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.5</td>
<td>b</td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cajanus sp.</td>
<td>f.2</td>
<td>w.12</td>
<td>f.12</td>
<td>w.12</td>
<td>w.2</td>
<td>w.2</td>
<td>f.4</td>
<td>w.2</td>
<td>f.1</td>
<td>w.1</td>
<td>f.1</td>
<td>f.1</td>
<td>w.1</td>
<td>f.1</td>
<td>f.1</td>
<td>f.8</td>
</tr>
<tr>
<td>Crotonaria crispa</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>w.1</td>
<td>f.1</td>
<td>f.1</td>
<td>w.1</td>
<td>f.1</td>
<td>f.1</td>
<td>f.1</td>
</tr>
<tr>
<td>Desmodium sp.</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>b</td>
<td>f.1</td>
<td>w.1</td>
<td>f.1</td>
<td>f.1</td>
<td>w.1</td>
<td>f.1</td>
<td>f.1</td>
<td>f.1</td>
</tr>
<tr>
<td>Digitaria sp.</td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythroxylum ellipticum</td>
<td>f.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eucalyptus tetradonta</td>
<td>w.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euphorbia sp.</td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycine clandestina</td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heteropogon contortus</td>
<td>f.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lotus sp.</td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opelia amentaceae</td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owenia vernicosa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum sp.</td>
<td>f.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persoonia falcata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminalia latipes</td>
<td>w.2</td>
<td>b</td>
<td>f.2</td>
<td>w.1</td>
<td>f.2</td>
<td>b</td>
<td>f.3</td>
<td>w.1</td>
<td>f.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitex glabrata</td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unidentified</td>
<td>&gt;200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>f.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

J1-9 (Jinmium surface sites 1–9). M10–16 (Marralam surface sites 10–16).
w denotes whole seeds; f denotes fragmented seeds; ub denotes unburnt seeds; b denotes burnt seeds.
cliff within a sheltered gorge. Two trenches were excavated in the deepest area with a sandy floor: PP1 was excavated close to the drip line, and PP2 approximately 5 m away close to the back wall. Both pits are characterised by loosely packed sandy sediment with a high charcoal content. The maximum depth was 90 cm in PP1, with cultural material in the upper 60 cm. The stratigraphy of the pit was characterised by predominantly loosely packed sandy sediment with a high charcoal content. Both pits contained a variety of cultural materials including flaked stone, grinding stones, stone points, bone, ochre, shell and glass. PP2 sediment is very dry and loose, and likely to be disturbed and mixed by kangaroo hollows.

Fruit tree seeds dominate all units of the PP1 seed assemblage (Figs. 9, 10). B. obovata, T. latipes and Terminalia ferdinandiana form the major components of both the >4 mm and 2–4 mm fractions. A major peak of P. falcata and B. obovata seed fragments was recovered from spit 6B (33–43 cm). Associated stratigraphic evidence indicates that this is a pit dug into spit 6. All of the seeds more than 15 cm below the surface were burnt. The species assemblage in pit PP2 is also dominated by fruit tree species.

5. Discussion

5.1. Distinguishing seeds deposited by cultural and non-cultural means

The modern seed assemblages are characterised first by the high density of grass and other small seed species, and second by spatial concentrations of mostly unburnt fruit tree seeds near the parent tree. Small seeds such as those of Panicum sp. or Y. majuscula are fairly light and...
Fig. 4. C1/III Pit, Jinmium, Species Assemblage >4 mm. Species assemblage from pit C1/III from the >4 mm fraction. Numbers of whole and fragmented seeds are measured per litre. 14C (AMS) dates are sourced from Persoonia falcata seed material dated at the Waikato dating laboratory (these results are presented in Table 2).

<table>
<thead>
<tr>
<th>Site</th>
<th>Depth (cm)</th>
<th>Spit</th>
<th>Material</th>
<th>Technique</th>
<th>Age ±</th>
<th>Lab. code</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1/III</td>
<td>33–39</td>
<td>10B</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>1050±60</td>
<td>Wk7691</td>
</tr>
<tr>
<td>C1/III</td>
<td>33–39</td>
<td>10B</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>1210±60</td>
<td>Wk7692</td>
</tr>
<tr>
<td>C1/III</td>
<td>80–84</td>
<td>18A</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>1060±70</td>
<td>Wk7693</td>
</tr>
<tr>
<td>C1/III</td>
<td>127–137</td>
<td>25A</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>3400±60</td>
<td>Wk7694</td>
</tr>
<tr>
<td>G1/I</td>
<td>22.4–27.6</td>
<td>6</td>
<td>charcoal</td>
<td>conventional 14C</td>
<td>200±60</td>
<td>Wk7301</td>
</tr>
<tr>
<td>G1/I</td>
<td>43–48.75</td>
<td>10</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>2620±60</td>
<td>Wk7696</td>
</tr>
<tr>
<td>G1/I</td>
<td>43–48.75</td>
<td>10</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>2970±70</td>
<td>Wk7695</td>
</tr>
<tr>
<td>G1/I</td>
<td>118.43–128.14</td>
<td>20</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>contaminated</td>
<td></td>
</tr>
<tr>
<td>G1/I</td>
<td>96.83–107.75</td>
<td>18A</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>1780±90</td>
<td>Wk7895</td>
</tr>
<tr>
<td>G1/I</td>
<td>96.83–107.75</td>
<td>18A</td>
<td>charcoal</td>
<td>conventional 14C</td>
<td>6170±300</td>
<td>Wk7302</td>
</tr>
<tr>
<td>G1/I</td>
<td>128.14–135.33</td>
<td>21A</td>
<td>charcoal</td>
<td>conventional 14C</td>
<td>3202±59</td>
<td>Wk7303</td>
</tr>
<tr>
<td>G1/I</td>
<td>107.75–118.43</td>
<td>19</td>
<td>pit sediment</td>
<td>TL</td>
<td>8400±100</td>
<td>W2459</td>
</tr>
<tr>
<td>PP1</td>
<td>33.25–43.25</td>
<td>6B</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>3330±60</td>
<td>Wk7699</td>
</tr>
<tr>
<td>PP1</td>
<td>33.25–43.25</td>
<td>6</td>
<td>charcoal</td>
<td>conventional 14C</td>
<td>3500±100</td>
<td>Wk7700</td>
</tr>
<tr>
<td>PP1</td>
<td>33.25–43.25</td>
<td>6</td>
<td>seed fragment</td>
<td>14C AMS</td>
<td>3540±70</td>
<td>Wk7698</td>
</tr>
</tbody>
</table>
may be moved or blown around a large area quite readily. Their widespread distribution most likely reflects this process. Fruit seeds may also be moved by birds, but in general, the main component of seed assemblages underneath a large fruit tree are seeds of the same species. Large and or heavy seeds are not well distributed away from larger fruit trees.

The upper Units of each of the rockshelter excavation pits contain a significant component of grass, other small seed species and/or fruit tree seeds, most of which are unburnt. The high density of grass seeds and low density of unburnt fruit seeds (similar to the off-site assemblages) support the idea that the upper Units as defined are essentially non-cultural assemblages. The whole unburnt seeds in the upper layers of CI/I–III were probably introduced to the site through chance distribution by birds, since this site is not overhung by fruit trees. Fruit seeds in the upper layers were always found in relatively low densities. There are no perches or crevices underneath the C1 rockshelter and it would seem a fairly unsuitable site for animal seed caching. The topography of the sand sheet surrounding the shelter is also quite flat so it is unlikely that seeds would collect there by rolling or water deposition.

In contrast, the high densities of burnt fragments of *B. obovata* and *P. falcata* seeds in the lower levels of all sites are considered to be cultural (Fig. 11). Processing of *P. falcata* and *B. obovata* has been recorded in a number of north Australian ethnographic and archaeological studies. Smith and Kalotas [31] and Kenneally et al. [22] describe the processing sequence of *P. falcata* by the Bardi people from the western Kimberley. In this case “the edible fruit (is) usually collected from the ground and eaten raw when ripe [yellow]; (or the) edible seed pounded, (and) mixed with water to make a black custard” ([22]: 171). *B. obovata* also has extremely hard seeds and we have recorded a similar processing sequence of *B. obovata* by senior members of the Marralam community. Both species are known as wet season fruit sources to local Aboriginal senior women. The fruit is picked or collected when ripe, mashed into a paste with a large stone and often mixed with sugar.

![Graph](image-url)

**Fig. 5. C1/I Pit, Jinmium, Species Assemblage 2–4 mm.** Species assemblage from pit C1/I from the 2–4 mm fraction. Numbers of whole and fragmented seeds are measured per litre. No seed material was dated from this pit.
The mash is consumed raw and any seed spat out (for full details see [16]). Processing such as described above would account for the fragmentation.

With regard to the seeds being burnt, Smith and Kalotas [31] report that because *P. falcata* seeds are so hard, they are pounded and warmed in hot ash. Crawford ([8]: 46–47) noted that *P. falcata* fruits at Kalumburu in the west Kimberley were sun-dried, cooked in ashes, hammered and then stored in paper-bark. The high density of *P. falcata* seeds in the inferred cooking pit at Punipunil is consistent with this process. We have found no records of *B. obovata* having been burnt in this way but the burnt nature and consistent size (dominating the 2–4 mm fractions) of both species in the seed assemblages suggest they have both been processed in a manner similar to that recorded above. It is possible that the cooking process makes the tough seeds easier to open, as with other hard seeds (e.g. *Macadamia* sp.). While it is also possible that the fruits were first smashed and the hard seed coats discarded in the fire (a procedure used to discourage ants in a camp site, Wightman, pers. comm., 1998), it is difficult to determine the exact order of processing events from the remains themselves. What is clear is that each of the three rockshelters has been an important focus for fruit processing. The implications of potential storage provided by dried fruit cakes are considerable, and could relate to situations of resource scarcity, travel and/or ceremonial activity.

5.2. Chronology, taphonomy and the onset of fruit seed processing

The onset of sustained fruit seed processing occurred about 3500 BP at Punipunil I, with comparable dates for bulk charcoal and *P. falcata* seeds in Unit 2. The lowest seeds occur slightly above the lowest cultural material in this site. There is flaked stone (≥4 mm) in spit 7 (unit 1) of PP1 and the lowest seeds are in Spit 6 and 6B (Unit 2) of PP1.
At Granilpi abundant seeds at the base of the charcoal-rich Unit 2 suggest an onset at about 3000 BP. Occasional seed fragments occur in the lower sandy Unit 1, but we cannot rule out down-profile movement of seeds and small charcoal fragments. The latter explanation would account for the seed date of 1780 ± 90 (Wk7895) at a depth with a bulk charcoal date of 6170 ± 200 (Wk7302). High frequency of stone artefactual material to the base of the deposit indicates that occupation of the site occurred well before the onset of seed processing.

At Jinmium the oldest seed date is 3400 ± 60 (Wk7694) at 132 cm, with the most intensive deposits in younger layers. Seeds from the lower units of CI/III were noticeably weathered. This and the more gradual decline in seeds with depth (compared to the more abrupt changes at Granilpi) indicate that preservational factors rather than actual onset of the activity are influencing the record more at Jinmium. The chronology provided by the seeds does not, on its own, suggest any significant movement of seed material within the CI/I, II or III trenches, although movement of carbon material and mixing of sediment below 1 m depth are indicated by the range of radiocarbon dates (conventional, AMS, and elemental carbon) and luminescence age estimates (TL and OSL; multiple aliquots, single aliquots and single grain) discussed by Roberts et al. [27]. The oldest seed date is quite consistent with the seed chronology as a whole, although its depth well below any stone points – that here and elsewhere in the study area are consistently younger than about 3500 years – lends support to arguments for significant movement and/or mixing in
Unit 1 sediments. On the other hand, the date is consistent with a Holocene chronology for human occupation in Unit 1 (contra [11]), as proposed by Roberts et al. [27].

5.3. Spatial and temporal trends in fruit seed processing

Any exploitation of fruit in the region would have been a highly seasonal activity, since the timing of fruit availability is locked in to the timing of the wet season, which has considerable monthly variation. Both species flower between July and October and fruit between October and December, but fruiting is also recorded in the literature through January and February [7,29]. Occupation of the rock shelters to process fruit is thus most likely to have taken place sometime between October and February, coinciding with the onset and development of the monsoon.

Within individual sites, particularly intense phases of fruit seed deposition occur, for example in Jinmium pit III about one thousand years ago, with overlapping seed dates from samples more than 40 cm apart. However, the variability evident in the three Jinmium pits and two Punipunil pits suggests that these reflect spatial variability within sites (cf. [33]) rather than any sort of broader trend.

At all sites fruit seed processing was one of a number of activities being undertaken. For example, the Jinmium pit III phase also has high densities of ochre and stone points. At Granilpi there is also a correlation of seed processing with artefact densities including stone point production in the lower half of Unit 2. Initial evidence for exploitation of seeds seems to precede any direct evidence of stone point production [1].

One trend visible at all three sites is the decline in processed *B. obovata* and *P. falcata* seed fragments towards the top of each site. Above the decline in
processed fragments, both species only occur as whole and unburnt seeds, suggesting that they are non-cultural in origin. The upper units of each pit also contain a significant component of grass and other small seed species and or fruit tree seeds, most of which are unburnt, similar to the off site assemblages. Available dates and occurrence in these levels of post contact archaeological materials such as glass indicate a date for this phase within the last 150 years.

This phase is not simply one of site abandonment, but represents a reorientation in activities associated with the arrival of pastoralism. This includes intensification of point production at a number of sites (cf. [1,15]). Even so, since we know from ethnographic evidence that wet season occupation of many traditional sites was maintained during ‘holiday times’ from station work [26], it could be expected that fruit seed processing would be part of this occupation. Significantly however, during detailed mapping and observation of each excavated site [3], no viable or adult *P. falcata* were recorded in a minimum 1 km radius. The species is considered marginal at Jinmium and Granilpi and non-existent at Punipunil, with a small but regenerating population at Marralam. The most likely explanation is the shift to more intense late dry season fires as Aboriginal patterns of burning throughout the dry season were disrupted with colonisation. Intense fires have been identified elsewhere by Aboriginal people as impacting negatively on *P. falcata* flowering and fruiting [14,34]. Further research is needed on this issue.

6. Conclusion

The picture of plant use presented in this paper is an artefact of fortuitous taphonomic processes. Here preservation is a direct result of Aboriginal people burning and carbonising the particularly dense hard seeds as part of the fruit processing technique, a process
undertaken in a unique microenvironment, that is, small isolated sandstone rock shelters in the surrounding sandy plain.

While *P. falcata* and *B. obovata* were both found in high densities in each of the archaeological excavations, it is not suggested that these were the only plants processed. In fact, the morphology of the remains that were found suggests that it was only those species with hard, charred seed coats that survived decomposition. Fruits with more fragile seeds that were consumed raw, including *V. glabrata*, *T. ferdinandiana* and *T. latipes*, are strongly represented in the upper archaeological levels, but were presumably also eaten during earlier times for which the evidence has not survived as well. The archaeological record of even less well preserved plants such as yams and other tubers is being pursued in this project via studies into starch residues on stone tools.

Burning of the seeds through processing has enabled the cultural and non-cultural components to be quite clearly distinguished and allows us one window into long term and more recent patterns of Aboriginal plant use. This picture depicts seasonal and fluctuating occupation of the small sandstone rockshelters while fruit was available over the late Holocene. Nevertheless the ethnographic record allows us to give considerable life to the archaeological window. We know that, although short-lived, the wet season fruits provide abundant foods highly valued by both adults and children for their taste and ease of access. We can envisage large scale processing of the fruits by groups of women to facilitate longer term storage. The implications of such storage for travel, ceremonial gatherings and intergroup exchange are being considered in ongoing work that compares the fruit seed window with other archaeological windows such as those of stone artefacts and ochre.

In contrast however, evidence of fruit processing ceases with the arrival of pastoralism and changed fire regimes, suggesting a significant shift in peoples’ utilization of these rocky outcrops, and potentially also a change in the ecology of these environments.
Acknowledgements

We are indebted to Biddy Simon and Polly Wandanga of the Marralam community for collaboration over many years. Assistance with excavation and plant recording was provided by Maurice Simon, May Melpi, Paul Melpi, Iza Pretlove, Eileen Huddleston, and Ken Mulvaney. Funding was provided by the Australian Research Council and the University of Wollongong (Research Centre for Landscape Change).

References

[6] A. Clarke, Macroscopic plant remains, in: W. Beck, A. Clarke, L. Head (Eds.), Plants in Australian Archaeology, University of Queensland, St. Lucia, 1989, pp. 54–89.


