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Recovering, Analysing and Identifying *Colocasia esculenta* and *Dioscorea* spp. from Archaeological Contexts in Timor-Leste

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With an original centre of domestication still in dispute, taro (*Colocasia esculenta*) is widely known in South East Asia and the Pacific as a staple food. As with other root crops, however, its identification in archaeological contexts has been elusive as preservation of parenchyma tissue, the main food product, is unlikely in most circumstances. A recent archaeobotanical project in Timor-Leste aimed at the recovery, analysis and identification of charred plant materials. This paper deals with the potential identification of plant taxa from the Araceae and Dioscoreaceae families from archaeological sites there, using flotation and a Scanning Electron Microscope.

1. INTRODUCTION

Two fieldwork seasons were carried out in Timor-Leste in order to discover archaeological sites in which preservation of charred plant materials could provide a history of plant use covering the end of the Pleistocene and the Holocene. A first field season was undertaken in 2004, with sites located and test excavated in the regions of Baguia and Baucau (Oliveira 2006). In 2005, more comprehensive excavations took place at the Bui Ceri Uato Mane (BCUM) rockshelter, in Baucau, the only site shown from the previous season to contain significant amounts of charred plant remains (Oliveira 2006 and 2008).

Archaeological methods in the field involved excavation using artificial spits and the natural stratigraphy, the flotation of all excavated sediment, followed by wet sieving and pre-sorting. Furthermore, modern plant materials were recovered from around the excavated site, in order to be charred in the laboratory under controlled conditions, and used as reference by comparison with archaeological specimens. Additional methods of sorting, analysing and identifying charred plant remains were also used and these are detailed below.

After the two fieldwork seasons were conducted, it was decided to analyse supplementary charred plant assemblages recovered from other sites in Timor-Leste. These sites, excavated by Spriggs, O'Connor and Veth in previous years, are all caves and rockshelters and include Telupunu, Lene Hara, Macha Kuru 1 and 2, and Jerimalai. As charred parenchyma remains were only identified at BCUM and Telupunu (and prob. *Colocasia esculenta* only at the latter), only these sites will be referred to in this paper.

2. THE ARCHAEOLOGICAL SITES

BCUM is located in the Kaisido area of the Baucau Plateau, within the village of Osso Ua/Uaisa (Fig. 1). It is a rockshelter 30 metres wide by six metres deep (Fig. 2 and Fig. 3), facing west, and is about 2.5 kilometres from the present day coastline. It lies only 50 metres to the north of the original Bui Ceri Uato, excavated by Glover between 1966 and 1967 (Glover 1972, 1986), and although it is not mentioned in any of his publications it was presumably seen at that time.

The Baucau Plateau is the area where Glover did most of his fieldwork in the 1960s (Glover 1972, 1986). His research there comprised a series of test pits and excavations both near the coast and in the interior, near Venilale (Glover 1972, 1986). The Baucau raised coral reef plateau extends 20 kilometres inland from the sea, sloping upwards to the base of the central mountain chain and reaching there around 600 metres above sea level (GERTIL 2002). Rockshelters and caves have formed in the vertical faces of the sequential uplifted terraces, especially in the area closer to the coast. As most sites excavated by Glover contained significant amounts of charcoal, this area always seemed like a viable option to conduct further archaeobotanical investigations, and thus BCUM was test pitted in 2004 and more comprehensively excavated in 2005.

The eastern region between Com and Tutuala where the Telupunu site is located, on the other hand, is where António de Almeida, Mendes Corrêa and Ruy Cinatti carried out archaeological fieldwork in the 1950s (Almeida 1960; Corrêa *et al.* 1964; Almeida and Zbyszewski 1967). When archaeological work resumed in Timor-Leste, in 2000, Lene Hara cave was one

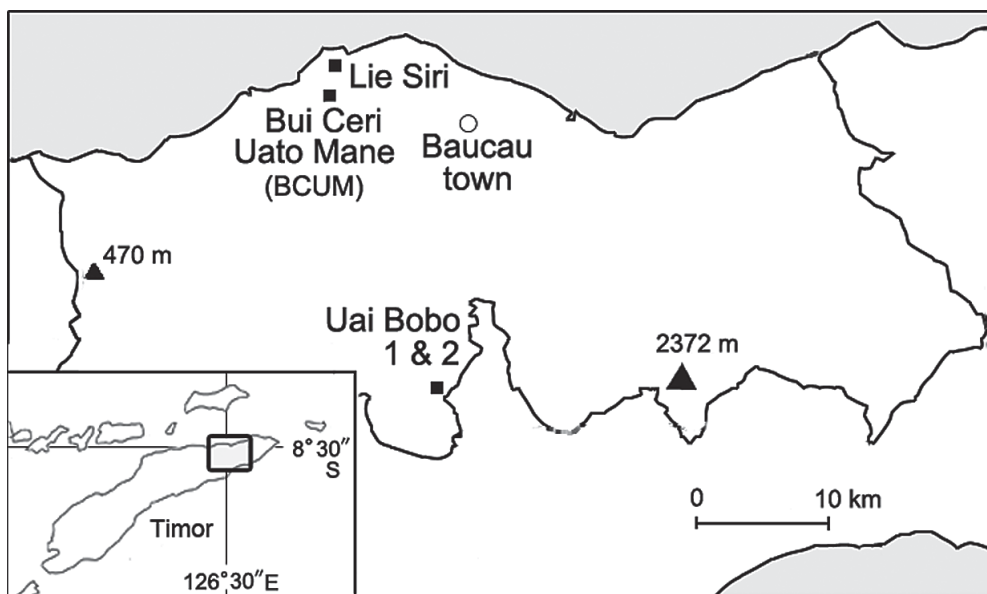


Figure 1 Location of BCUM in the Baucau area (map by E. Tabuchi)



Figure 2 Entrance to BCUM rockshelter, Baucau



Figure 3 A view from inside BCUM rockshelter

of the first sites to be investigated by the East Timor Archaeological Project (ETAP, see O'Connor *et al.* 2002a). Since then, many other sites there have been located and excavated, both within the ETAP project and later by O'Connor and other researchers. They range from shell middens, rockshelters and caves, to sites with rock art and small fortified settlements (O'Connor *et al.* 2002a, b; O'Connor 2003; Spriggs *et al.* 2003; Veth *et al.* 2004; Veth *et al.* 2005; Lape 2006; O'Connor 2007).

Telupunu, close to the village of Com, was excavated by Spriggs in 2002 and interpreted as used only occasionally, based on the low density of cultural material found (Spriggs pers. comm.; Veth *et al.* 2004: 223; Veth *et al.* 2005: 186, 187). Human occupation there extends back to the terminal Pleistocene, with a near-basal date of 16,937–15,976 cal BP (Spriggs pers. comm.; see also Oliveira 2008: 302 for all calibrated dates from this site). The preservation of hearth features and charcoal throughout Telupunu's stratigraphic sequence is notable. After BCUM, Telupunu contained the most comprehensive macrobotanical assemblage excavated in Timor-Leste.

3. METHODS USED TO RECOVER, ANALYSE AND IDENTIFY CHARRED PLANT REMAINS

After a 50×50 centimetre test pit, dug in 2004, confirmed the existence of large amounts of preserved charred plant remains at BCUM, it was decided to conduct more comprehensive excavations at this site the following year (Oliveira 2006 and 2008). The second excavation season took place between June and September 2005. The fieldwork method adopted was specifically aimed at systematically recovering charred macrobotanical remains, and this was achieved directly during the excavation process, through flotation and through wet-sieving.

A two by two metres grid was laid in close proximity to the area test pitted in 2004, divided into four 1×1 metre squares: A, B, C and D (Figs. 4 and 5). Excavation proceeded to a depth of about three metres, with the total excavated sediment reaching approximately ten cubic metres. Excavation employed arbitrary four to five centimetre units (spits) and also followed natural layers, with every excavated spit or layer recorded individually. Whenever preserved *in situ*, charcoal was recovered separately. In spits and layers which showed fire

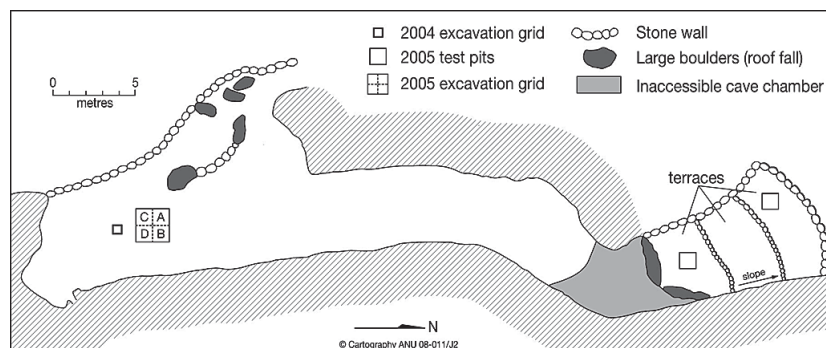


Figure 4 Plan of BCUM showing location of the main excavation areas (2004 and 2005)

episodes and good preservation of quantities of charred plant material, excavation proceeded with greater caution. All sediment excavated within each individual spit was kept separate, bagged, and transported to the nearby village of Osso Ua, where it was subject to flotation and wet-sieving (Figs. 6 to 10).

The process of flotation involved the use of standard plastic buckets, filled with 1/4 of sediment and 3/4 of water (Fairbairn 2005b). After waiting approximately 10 minutes for the heavier residue to settle in the bottom, the content of buckets with floating material was then slowly poured through a fine 0.05 millimetre chiffon mesh. The light residue thus retained in each chiffon mesh was carefully folded and put to dry in the shade. It was sorted while still in the field, allowing for the separation between charred plant remains and other buoyant materials. The remaining heavier sediment was then wet sieved and sorted, allowing for the recovery of less buoyant macro plant remains. Sediment weights of each excavated spit in the different squares were recorded, before and after flotation, and after removal of the charred plant remains recovered. Weight of total amount of charred plant remains was also recorded.

After flotation, the remaining sediment (heavy flot) was wet sieved through a one millimetre mesh-sieve, dried out and sorted by local villagers. It was then bagged by different types of material (charcoal, pottery, stone tools, shellfish, bone, etc.), and later analysed in the laboratory. A column of sediment samples was also retrieved from the eastern profile of square D, through five centimetre spits. These were later matched with the general stratigraphy of the site and used for phytolith analysis (Oliveira 2008: 345–361).

As for excavations at Telupunu (and most other sites excavated within the ETAP project), these were conducted using a combination of arbitrary two to five centimetre spits and natural layers (Spriggs, pers. comm.). Wet-sieving through a less than two millimetre mesh sieve (O'Connor *et al.* 2002a: 47; O'Connor 2007: 528), and flotation (O'Connor 2007: 529; O'Connor and Spriggs, pers. comm.) were generally used. The flotation method employed consisted in filling plastic buckets with sediment and water, and recovering buoyant charred plant material with a tea strainer. At Telupunu, dry-sieving employed a two millimetre mesh sieve. The heavy residue was taken to the camp site where flotation took place. The light flot (from this and all other sites) was then bagged and brought back to Canberra (Spriggs and O'Connor pers. comm.).

Analysis in the laboratory of the charred plant material recovered was done in a similar way for all assemblages, using low powered microscopes and SEM¹. Before this was done, though, wood charcoal (which has not been analysed) had to be separated from other plant materials, including parenchyma, seeds, fruit and nut remains, and nutshells. The identification of other plant parts was done with different degrees of confidence (Paz 2001: 71; Oliveira 2008: 325),² using a collection of modern reference material, against which archaeological specimens were compared. This collection was built using plant specimens collected in the field, specimens from the RSPAS collection, and reference to the Australian National Herbarium, in Canberra, as described in detail below.

Both assemblages, from BCUM and Telupunu, were too large for a complete analysis of all recovered plant remains to be fully undertaken, and had to be sub-sampled. Given the large amount of plant material retrieved from BCUM, it was decided to concentrate most of the analysis on square D. This square clearly had more charcoal than the others and seemed to

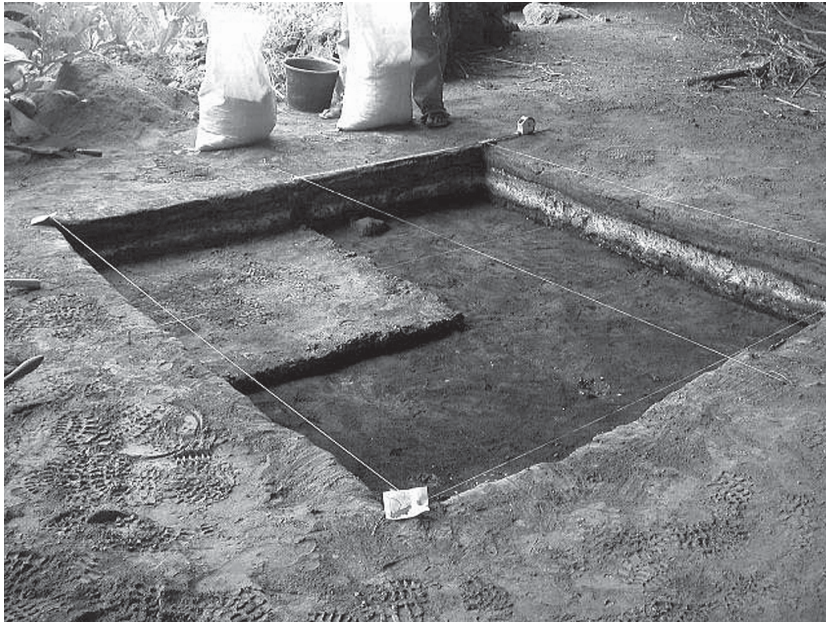


Figure 5 2×2 metre grid and detail of the 2005 excavations at BCUM



Figure 6 Adding water to sediment samples during flotation



Figure 7 Pouring sediment samples through fine chiffon during flotation



Figure 8 Wet-sieving heavy fraction samples



Figure 9 Drying light fraction samples (the flot)



Figure 10 Sorting through dried heavy fraction samples

have better stratigraphic integrity. Total charcoal per spit was first weighed and then separated, and was later analysed in different size fractions (between one and two millimetres, between two and four millimetres, and larger than four millimetres). This allowed for better microscopic observation of similar-sized fragments, as well as for a comparison of degrees of preservation between types of plant remains through the stratigraphic sequence.

Several spits from different stratigraphic units were analysed with the use of a low powered microscope ($\times 10$ to $\times 50$ magnification), in order to assess whether there were major changes in composition and diversity of preserved plant specimens throughout the sequence. Based on this preliminary assessment, it was decided to analyse the fractions between two and four millimetres and larger than 4 millimetres of all excavated spits in square D. Fractions between one and two millimetres in spits that contained pottery were also observed with a low powered microscope, in order to investigate whether smaller seeds from cereal crops were present.

Fragments were initially separated into different categories (e.g., seeds, fruit/nut shells, parenchyma, wood charcoal, etc.), with the use of low-powered ($\times 10$ to $\times 50$ magnification) and high-powered ($\times 100$ to $\times 1000$ magnification) microscopes, and kept in separate glass vials. These were then grouped into similar types within each category and compared with the modern reference material, using SEM. Wood charcoal was separated but not analysed, as its analysis involves a different methodological approach and would have required a more comprehensive collection of modern reference material.

The Telupunu macrobotanical remains came from test pits 1 and 2 and constitute the second most significant assemblage of charred plant material from all sites analysed in Timor-Leste. Final publication is still in process (Spriggs pers. comm.) and only two short notices are available for reference (Veth *et al.* 2004: 223; Veth *et al.* 2005: 186,187). All existing radiocarbon dates for Telupunu are from test pit 2. For that reason, it was decided to analyse the charred plant materials from this test pit in greater detail³.

4. ETHNOBOTANICAL BACKGROUND

The original centre of domestication of *Colocasia esculenta* is still disputed (Matthews 1990; Matthews *et al.* this volume; Lebot 1999: 623–624), but the plant is widely known all across South East Asia and the Pacific as a staple food. Its identification in archaeological contexts has been elusive as preservation of starchy parenchyma tissue the main food product, is unlikely in most circumstances. Microfossil evidence for its presence in New Guinea during the Early Holocene prompted the suggestion for a Melanesian domestication, followed by human translocation into Island Southeast Asia and the Pacific (Denham 2003; Denham *et al.* 2003; Denham and Barton 2006; Fullagar *et al.* 2006).

C. esculenta is one of the several root crops identified by Metzner (1977) and planted in the Timorese *to'os* (house garden). The main crop identified by Metzner in the *to'os* (the garden) was maize. Together with maize, other crops were identified, such as beans (the seeds of *Lablab purpureus* are usually planted together with maize), dry-land rice, and a variety of root crops, including *Manihot esculenta*, *Dioscorea* spp. (e.g., *D. alata*, *D. esculenta* and *D. hispida*), *Pachyrhizus erosus*, *Colocasia esculenta*, *Alocasia* spp. and *Ipomoea batatas*.

Metzner (1977: 125) observes that 'to avoid seasonal shortages, root crops are kept at several stages of development'. Taro was also observed under cultivation in the area investigated (pers. obs. 2005).

As for wild taro, it is probably native to a wide region, from Southeast Asia to the Australasian region (Purseglove 1972; Matthews 1990; Lebot 1999: 623–624). It is not mentioned by Metzner (1977) in Timor-Leste, and although it is not known whether it exists in there, it could be within its native area of dispersion. It was not observed in the area investigated (pers. obs. 2005).

Taro is most commonly known in Timor-Leste by its Austronesian Tetun name: *talas* or *keladi*. Still important in many areas of the country as a staple or complementary food, its importance in daily diets has been drastically reduced since the introduction of other staples brought by the first European settlers, namely corn, sweet potato and potato.

In the area under study, species of yam include *Dioscorea alata* L. (the Greater or White yam, known locally as *uhi*), *D. esculenta* (Lour.) Burkill (the Lesser or Chinese yam, known as *kumbili*) and *D. hispida* Dennst. (the Asiatic, Bitter or Wild yam, known in Tetun as *kuân*) (pers. obs. 2005).

Originally thought to have originated in Southeast Asia, *Dioscorea alata* is a cultigen of probable New Guinea origins, since its centre of genetic diversity lies in New Guinea (Lebot 1999: 624–625; Allaby 2007: 186 for a review). Today it has a wide distribution throughout the tropics (Burkill 1966: 826–828; Purseglove 1972: 100–101). Remains of *D. alata* have been identified in Sabah, Borneo, dated to ca. 2200–1500 BP (Paz 2005: 113). *D. alata* is referred to by Metzner (1977) as being planted in gardens around houses for its edible underground root, together with other tubers, cereals and pulses.

Dioscorea esculenta is probably native to Mainland Southeast Asia and it is not widely grown outside Asia and the Pacific (Purseglove 1972: 106). Evidence of *D. esculenta* in the archaeological record remains elusive. Recent microfossil research on starch residue places this species in Melanesia within mid-Holocene Lapita contexts (e.g., Horrocks and Nunn 2007). Metzner (1977) notes that *D. esculenta* is planted in house gardens together with other root crops, maize and beans. *D. esculenta* is cultivated for its edible and starch-rich underground tuber (Burkill 1966: 831; Ochse and van der Brink 1977: 222–226).

Dioscorea hispida is a wild yam of probable Southeast Asian origins, known to have been used for its edible properties since the Pleistocene (Barker *et al.* 2007; Paz 2005). It is also known as intoxicating yam, and needs to be detoxified before consumption (Ochse and van der Brink 1977: 252–255; Burkill 1966: 833; Purseglove 1972: 106). Metzner (1977) records *D. hispida* as being cultivated in gardens in the area under investigation.

5. BUILDING A COLLECTION OF MODERN REFERENCE SPECIMENS

To identify charred plant materials from archaeological sites, access to a comprehensive collection of modern specimens for comparative purposes is of primary importance. Scientific binomial identifications of archaeobotanical specimens should always be attempted by matching morphological and anatomical features in these and modern reference materials, together with an assessment of confidence level.

Comparing archaeological to modern plant assemblages is not straightforward for various reasons. Firstly, plant distributions and environmental zones change through time, so it is not expected that plant species found in archaeological sites correspond exactly to those existing in present surrounding environments. Secondly, there is significant phenotypic variation within wild species and cultivars, according to their genetic characteristics and responses to local environmental conditions. Thirdly, preservation of anatomical and other morphological features in archaeological specimens is generally poor and does not always permit a perfect match (e.g., to species level) with modern materials.

In this context, the more comprehensive the reference collection of modern charred plant materials, the better the chance of matching with the archaeological specimens. It was decided to build a reference collection of modern plants consisting of specimens for analysis and for preservation as herbarium specimens. As most archaeological specimens under investigation were fragments of fruits, nuts, seeds and tubers, vouchers of such parts from modern plants were collected. The first stage involved collecting specimens from around BCUM (Fig. 11; cf. Paz 2001: 57). While in the field, a list with around 75 names both in Tetun and Uaima'a was compiled by Sr. Augusto Belo, the head of Osso Ua/Uaisa village. These are edible or otherwise economically useful plants currently known to villagers living around BCUM. Of these, only 30 contained edible seeds or nuts and were matched with their correspondent scientific, English or Portuguese names. Individual specimens of these were collected⁴). This part of the reference collection was far from the known number of plants currently in use around the excavated site, and we can assume that the range of species used in prehistory was wider than that collected in the field. Further data were needed.

The only systematic ethnobotanical research within the field area was published by Metzner (1977). Metzner reported many more species than those I was able to collect in 2005, so the modern reference collection was complemented with specimens existing in the Department of Archaeology and Natural History at the ANU, and with nuts and seeds from the Australian National Herbarium in Canberra. A few important edible species of presumed New Guinea origins were also added, despite the fact that they were not reported by Metzner in the area investigated. They are, however, known to exist elsewhere in Timor-Leste.

Some species that may have been important in the past are still not part of the collection, either because they were not recognised during fieldwork, or because the herbarium specimens examined or available did not contain fruits or seeds. Andrew Fairbairn provided further reference specimens, already charred, and Victor Paz also made some SEM images available from his own reference collection (including those of *Dioscorea hispida*). Modern fragments of both *D. alata* (Figs. 12 and 13), *D. esculenta* (Fig. 14) and *Colocasia esculenta* (Figs. 15 and 16) were provided by Emilie Dotte and charred at ANU.

6. IDENTIFYING *COLOCASIA ESCULENTA* AND *DIOSCOREA* SPP.

As mentioned above, fragments of charred parenchyma tissue were only identified at two of the assemblages analysed, and only the Telupunu site contained one small fragment identified as prob. *Colocasia esculenta*. In BCUM, only two parenchyma fragments were identified as prob. *Dioscorea* spp., and these came from layer 12, from which two radiocarbon determina-

tions of 5920–5710 cal BP and 5612–5315 cal BP were obtained (Figs. 17 to 20; and see Oliveira 2008).

It should be noted that no cell measurements were undertaken on any of the parenchyma fragments analysed (see Paz 2001: 188–192 for application of the determination system to *Dioscorea*)²⁾ and for that reason identifications suggested here are based on a general comparison with existing reference material. Despite that, the cells in both the archaeological specimens and the reference material seem to be of a similar size and shape. Both archaeological fragments from BCUM presented angular to round cells, with very thin walls and almost no intercellular space, which conform to the Dioscoreaceae family.

Dioscorea alata, *D. esculenta* and *D. hispida* were reported by Metzner (1977) as species present in gardens in the area he investigated, and these were also observed during fieldwork in 2005 (pers. obs.). At this stage, the impossibility of ascribing the identified *Dioscorea* specimens to any of these species renders interpretation difficult and it is not possible to assess whether they are more likely to be wild or cultivated yams.

One parenchyma specimen from Telupunu was the only parenchyma fragment identified as prob. *Colocasia esculenta* (Figs. 21 and 22). This came from a spit within a pre-ceramic layer, and was directly dated by AMS to 3360–3160 cal BP. There may have been some minor disturbance at the pottery to pre-pottery interface (Oliveira 2008). As noted above for the specimens identified as members of *Dioscorea*, no cell measurements were undertaken on any of the parenchyma fragments analysed (see Paz 2001: 178–185 for the application of the determination system to Araceae). However, a general comparison between the archaeological specimen and the existing reference material revealed the presence of rounded and angular parenchyma cells of similar size, with very thin walls and some intercellular space between them. One of the traits that seems to be diagnostic in this species, and which was not observed in any other parenchyma examined, is the presence of very distinctive vascular bundles within the parenchymatous tissue (Fairbairn pers. comm.). Some of these bundles are still preserved in the reference specimen analysed, but seem to have disappeared in the archaeological specimen, leaving only a pronounced cavity inside which the inner walls are still visible.

Colocasia esculenta is still widely used today and was observed under cultivation in the area investigated (pers. obs. 2005). Despite not being a faithful match, the similarities observed in the archaeological and reference specimens allow identification of the former as prob. *C. esculenta*.

7. DISCUSSION AND CONCLUSIONS

Regarding the nature of food types consumed in archaeological sites and their archaeobotanical expression, the better that plant management practices are ethnographically documented the more we can learn about how food plants are processed and preserved archaeologically. As Paz noted, there seems to be a correlation between the different ways in which *Colocasia* and *Dioscorea* are prepared and consumed and the way they preserve archaeobotanically, with the first more exposed to accidental charring and thus more commonly found in archaeological sites (Paz 2001: 269).

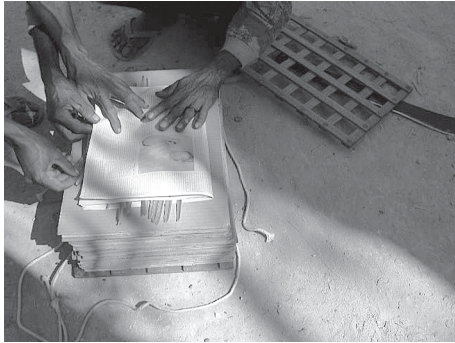


Figure 11 Collecting modern plant specimens from around BCUM

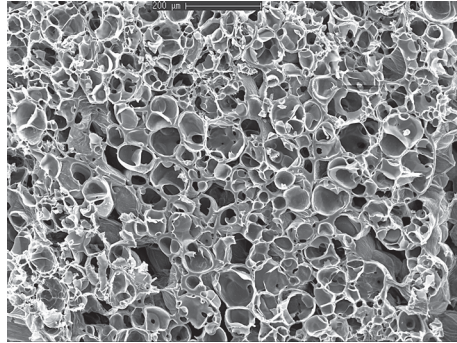


Figure 12 Modern specimen of *Dioscorea alata* (100×, radial/longitudinal section)

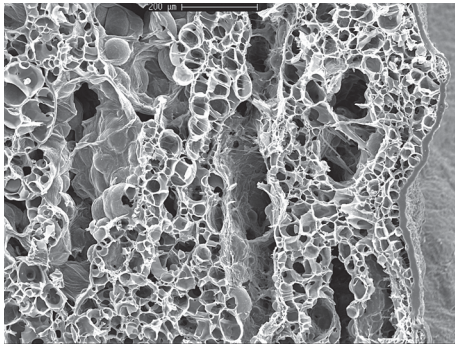


Figure 13 Modern specimen of *Dioscorea alata* (100×, radial/longitudinal section)

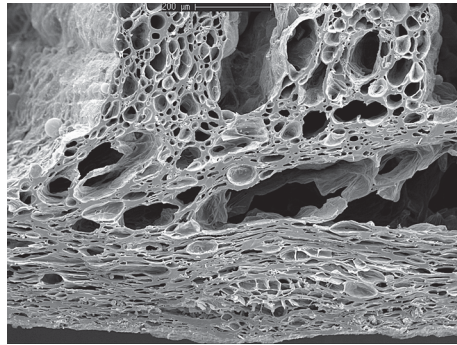


Figure 14 Modern specimen of *Dioscorea esculenta* (100×, transversal section)

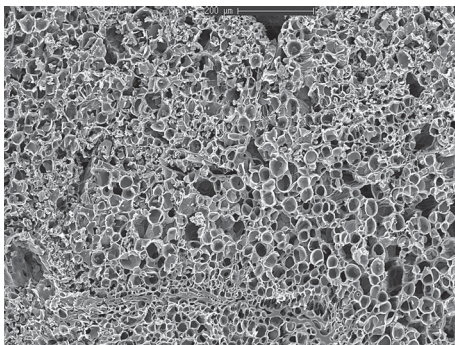


Figure 15 Modern specimen of *Colocasia esculenta* (100×, radial/longitudinal section)

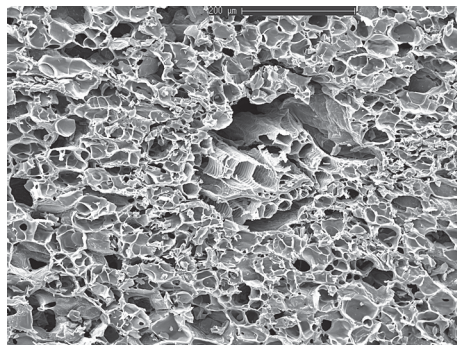


Figure 16 Modern specimen of *Colocasia esculenta* (150×, transversal section)

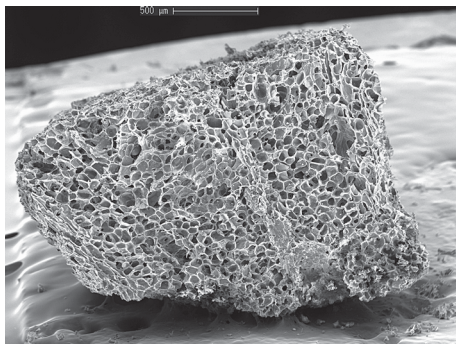


Figure 17 Prob. *Dioscorea* sp. from BCUM—sample 1 (45×)

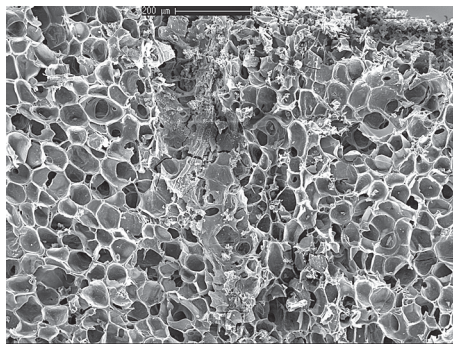


Figure 18 Prob. *Dioscorea* sp. from BCUM—sample 1 (100×)

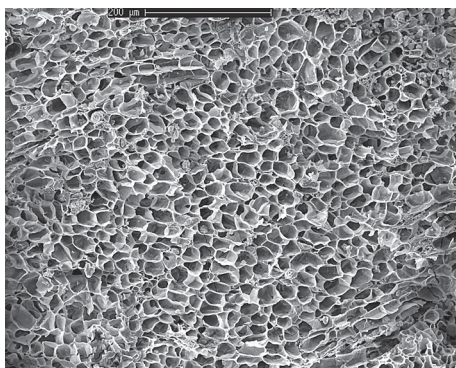


Figure 19 Prob. *Dioscorea* sp. from BCUM—sample 2 (150×)

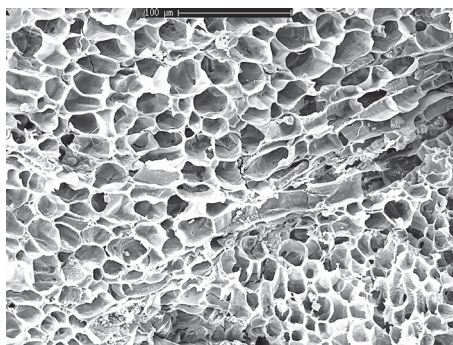


Figure 20 Prob. *Dioscorea* sp. from BCUM—sample 2 (300×)

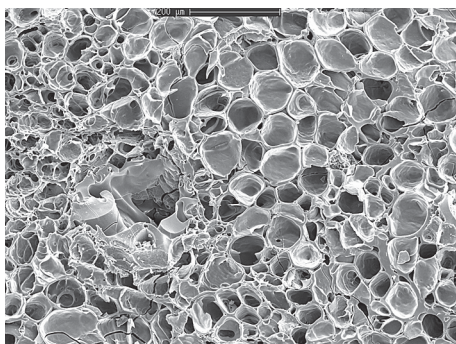


Figure 21 Prob. *Colocasia esculenta* from Telupunu (120×)

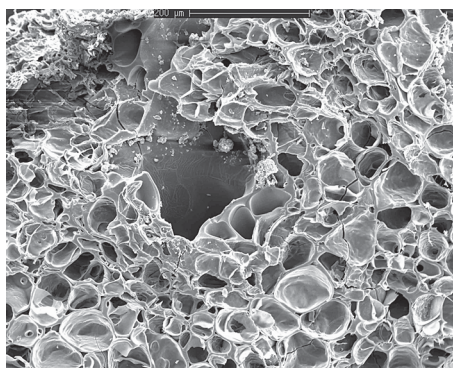


Figure 22 Prob. *Colocasia esculenta* from Telupunu (150×)

Here, identification of parenchyma tissue from the mid-Holocene in Timor-Leste can only be reported as ‘probable’ (prob. *Colocasia esculenta* and prob. *Dioscorea* sp.). Remains of these taxa usually preserve poorly in the archaeological record and additional evidence is desirable. The above methods for recovering, analysing and identifying charred plant materials from archaeological sites do provide valid results, but to achieve greater confidence in the identification of archaeobotanical specimens, more comprehensive modern reference materials and a better knowledge of the local ethnobotany are necessary.

Most plant identifications in this study were made using SEM. When the identified remains are compared with the totality of charred plant material recovered for each site (or with just the plant material ascribed to non-woody categories), it is apparent that only a very small fraction of specimens was analysed using this technique. For this reason, quantification of the occurrence of each identified species is not possible at this stage. The only exceptions are specimens for which identification—even if at a lower level of confidence—is possible using low-powered bifocal or stereoscope microscopy only (e.g., morphologically distinctive seeds, when intact). This is not possible for parenchyma tissue. Parenchyma, which comprises the most part of tuber-like plant organs, is more easily affected by post-depositional factors and is thus rare (Oliveira 2008: 237). Even when post-depositional conditions are conducive to the preservation of charred plant materials, as they were at BCUM and Telupunu, very few remains of the non-woody types—especially parenchyma tissue—are preserved. If the agricultural signal we are looking for is one based on a diverse range of root and tree crops rather than a single dominant crop, it will be more difficult to recover good sample sizes of identifiable plant material.

The agricultural practices observed during fieldwork in 2005 around BCUM confirmed the use of a diverse range of food plants, including tubers, as had been previously noted by Metzner (1977). In an unpredictable environment where prolonged dry weather and an irregular wet season are the norm, diversity of resource exploitation seems to be the preferred subsistence strategy to avoid potentially catastrophic food shortages. The archaeobotanical record from Timor-Leste appears to reflect this type of strategy, since a diversity of plant species in small amount rather than a large amount of one species was recorded.

Overall, the archaeobotanical information from Timor-Leste (Oliveira 2008) suggests a complex scenario of early plant management in the island. Despite the taphonomic problems and variable preservation, and the fact that it was not possible to compare the newly acquired specimens from the suites of plants analysed within this study and Glover’s published material, it is clear that diverse root and tree crops have been in use in Timor-Leste since the early Holocene and possibly the late Pleistocene (Oliveira 2008). The charred plant assemblages analysed from all sites in Timor-Leste suggest that a number root crops as well as fruit and nut trees with important economic uses, have long played a role in the subsistence system strategies used by prehistoric populations in Timor-Leste. With the exception of prob. *Colocasia esculenta* and members of the Fabaceae family (only present in pottery-bearing layers of the sites analysed), all economic plant remains identified were present and presumably targeted by human groups in Timor-Leste since the early- to mid-Holocene and possibly the late Pleistocene (Oliveira 2008). It is possible that *C. esculenta*, the remains of which preserve poorly and so are difficult to detect, was present in Timor at an earlier period, but this cannot

be confirmed here.

The new archaeobotanical data suggest a continuum of food plant exploitation during several millennia with no major changes registered across the pottery-transition boundary around 3800–3600 cal BP. Indeed, the record obtained through both the macrobotanical analysis and the phytolith data (Oliveira 2008: 345–Appendix 33) suggests a continuum of strategies punctuated by some introductions and adaptation, rather than substantial changes or discontinuity motivated by replacement.

If we except the identification of *C. esculenta* (for which there is much older evidence further east in New Guinea, *cf.* for example Denham 2003, and Denham *et al.* 2003) and the Fabaceae remains (only present at Telupunu within the last ca. 1200 years), the emergent picture in terms of plants with the potential for food production in Timor-Leste is one where the major changes only occurred within the last ca. 500 years, after the first European contacts.

In practical terms, these conclusions point to the need to investigate matters of past plant management practices primarily through direct lines of evidence, such as macrobotanical remains and phytoliths. Indirect evidence such as the presence of pottery or animal domesticates can be misleading. A ‘focus on a contextual understanding of plant use practice’, as Fairbairn (2005: 16) defines it, and systematic flotation and wet-sieving techniques as ways of recovering evidence of food plants from archaeological sites (preferably, at the onset of archaeological projects), are among the approaches fundamentally needed to understand the uses people made of plants in the past. Ethnographic information on current plant uses, and genetic studies of plant origins and trajectories are also fundamental.

In the case of BCUM and Telepunu, the emerging subsistence picture is one of dependence on underground plant food sources, an impoverished wild fauna during the late Pleistocene and most of the Holocene, domesticated animals from ca. 3800–3600 cal BP, and marine foods such as sea urchin, crab, fish and especially shellfish, since at least the mid-Holocene.

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NOTES

- 1) All SEM work was carried out at the ANU Electron Microscopy Unit (EMU), under the supervision of Geoffrey Hunter and Cheng Huang. All archaeological specimens were initially dried for 48 hours in a furnace. After drying, both archaeological and modern charred materials were fractioned

and prepared using 12.6 millimetre stubs, double-sided conductive tape and nail varnish. All samples were again kept in a furnace for a couple of days, after which they were gold-coated. Gold coating and the technical use of the SEM were carried out following EMU's technical specifications (Hunter pers. comm.).

- 2) The identification of all archaeological charred plant specimens from Timor-Leste was done using the same determination system adopted by Victor Paz (2001: 71, Fig. 7):

Non prefixed: photographic reference(s) and/or illustration reference(s); reference material not essential; exact fit of the taxonomic features, geographic distribution, and species citation in the local flora;

Prob.: flora citation, geographic area compatibility, an agreement with taxonomic details; image OR illustration OR reference material (not necessarily an exact or good fit);

Cf.: all six categories may or may not exist; archaeological specimen resembles image OR illustration OR reference material OR previous identification; flora, taxonomic details and geographic area but with doubts;

Elim.: lowest level of confidence for a binominal determination to species level, but with no access to image, illustration or reference material; taxonomic description, geographic area and other species of same genus were eliminated from local/regional flora (= likely candidate);

Suffix 'type': very low level of confidence, used only at family and genus level of determination; shape of specimen fits the geographic distribution, some morphological characters, and may be in the local flora;

Form shape description: none of the six types of information exist (image, illustration, reference collection, flora, taxonomic details and geographic area), but specimen is distinctly a seed, nut fragment or a certain plant part.

Shape: spheroid, angular/triangular, long, etc.; sequence number; tentative identification, usually at family level.

- 3) All radiocarbon dates were calibrated using both online versions of Calib. 5.2 (determinations up to 21,380 uncal BP; Stuiver and Reimer 1993, Version 5.0.2), and CalPal 2007 (older than 21,380 uncal BP determinations; Weninger *et al.* 2007). These dates are presented with 95% probability at 2σ (sigma). As to calibration of dates obtained on marine shell, the global ocean reservoir correction of about 400 years (incorporated within calibration) has been used. As there are no specific data for Timor-Leste, no differences in Delta R (ΔR) for the local region have been calculated.

Three different dating laboratories provided the radiocarbon dates obtained for sites under analysis: ANU Radiocarbon Dating Laboratory, (ANU), the Waikato Radiocarbon Dating Laboratory (Wk), and ANSTO (OZJ and OZK). Dates obtained through Accelerator Mass Spectrometry are simply referred to as AMS.

- 4) Lyn Craven and Frank Zich, at the Australian National Herbarium, later confirmed the identification of species collected in the field. The protocol for collecting plant specimens was the one used by the Australian National Herbarium (Craven pers. comm.).

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