RE-DATING MID-HOLOCENE BETELNUT (ARECA CATECHU L.) AND OTHER PLANT USE AT DONGAN, PAPUA NEW GUINEA

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ABSTRACT. Direct accelerator mass spectrometry (AMS) dating of anaerobically preserved plant remains from the Dongan site in New Guinea, combined with assessment of preservation condition, confirms earlier doubts about the antiquity of betelnut (Areca catechu L.) found at the site. A possible sago leaf fragment is also identified as a modern contaminant. The mid-Holocene age of other fruit and nut remains is verified using these methods. The utility of AMS dating in combination with detailed archaeobotanical assessment is demonstrated, thus improving chronometric hygiene and with it knowledge of past plant use in Oceania.

INTRODUCTION

Archaeological excavations at Dongan, located on the edge of the Bosman Plateau in the Sepik-Ramu Basin of northern Papua New Guinea, provided some of the earliest evidence in the Pacific region for use of a complex suite of edible fruits and nuts by prehistoric populations (Swadling et al. 1991). Preserved in waterlogged anaerobic sediments, the plant assemblage contained large fragments of nuts and fruits from food species such as galip nut (Canarium sp.), coconut (Cocos nucifera L.), screwpine (Pandanus sp.), and the stimulant betelnut (Areca catechu L.), as well as a leaf fragment tentatively identified as sago (Metroxylon sagu Rottb.) (Yen and McEldowney 1991). Three conventional radiocarbon dates derived from wood charcoal associated with the fruit and nut remains produced a date range of ~5500–6000 14C BP (for dates and calibrated ranges see Table 1, samples a, b, and e). Mid-Holocene exploitation of these regionally important tree-crop species in New Guinea challenged the dominant view that crops, as well as agricultural techniques, were introduced to Oceania from Southeast Asia along with Lapita pottery 3 to 4 kyr BP (see Kirch 1989; Spriggs 1996; Kennedy and Clarke 2004). In particular, the betelnut find prompted a great deal of interest. It is today a stimulant of global importance that is usually considered, on phytogeographical and linguistic grounds, to have spread from a center of domestication in Southeast Asia into Oceania (Lichtenberk 1998). Its pre-Lapita presence at Dongan hinted at different domestication and/or dispersal histories and has been interpreted as signifying pre-Lapita New Guinea-Asia connections (see Yen 1993; Denham 2004).

The Dongan assemblage was of sufficient importance to be reanalyzed as part of a project to investigate plant food production in lowland New Guinea, using new macrobotanical identification techniques. Suspicions were raised about the antiquity of both the betelnut and sago fragments during preparatory work. These mirrored published doubts about the antiquity of the betelnut find based on its apparent freshness in published photographs (original photo, Swadling et al. 1988: Figure 38 inset; for criticism see Spriggs 1996:328). A combination of archaeobotanical observations and direct accelerator mass spectrometry (AMS) dating was used to investigate whether these fragments, and the assemblages of which they were part, were indeed of mid-Holocene date.

MATERIAL AND METHODS

Dried archaeological plant remains from the Dongan excavation were released by the National Museum and Art Gallery of Papua New Guinea, and examined and identified using morphological

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and anatomical characters in comparison to verified modern plant specimens. A low-powered dissecting microscope was used for much of the work, with the scanning electron microscope (SEM) used for detailed investigation of specimen anatomy. Notes were made of each specimen’s preservation condition (shape, degree of distortion, compaction, flexibility, evidence of decay/erosion, and dirtiness) as a key indicator of source and possible age. The fruit and nut specimens were large enough to provide samples for AMS dates. The specimen of betelnut (0.11 g) from spit 16 (Figure 1) and a large specimen of *Canarium* sp. nutshell (0.65 g) from spit 14 (Figure 2) were AMS dated at the Waikato Radiocarbon Dating Laboratory, New Zealand, following standard procedures (see http://www.radiocarbondating.com/) and calibrated using OxCal v 3.10 (Bronk Ramsey 2005). The betelnut husk was dated to check its antiquity, as it was a suspected intrusive element, while the *Canarium* specimen was dated as a representative of the rest of the assemblage (see below).

**RESULTS**

Fruit remains of *Canarium* sp., *Cocos nucifera*, and *Pandanus* sp. were confirmed in the assemblage, with *Pometia* sp. also probable. The shape and anatomy of several *Canarium* fragments were consistent with domestic *C. indicum*, but full distinction from other *Canarium* species was not possible. Since the betelnut husk had lost its distinctive outer pericarp layer, the identification on morphological grounds was changed to *Areca* sp., as it could have come from several *Areca* species. Anatomical and morphological details show that the possible sago leaf was clearly from the palm family (Arecales) (Tomlinson 1961), but higher-level (e.g. genus, species) identification is not secure, hence the identification remains as “Arecaeeae type.” Identifications of other taxa reported in Swadling et al. (1991), most of which were considered questionable or unlikely (Yen and McEldowney 1991), have not been confirmed.

Some charred specimens of *Canarium* and *Cocos nucifera* were present in the site assemblage, but most identified remains were preserved as a result of decay suppression in the anaerobic conditions of the source sediments. With only the exceptions detailed below, all of the uncharred specimens
were darkly stained; showed signs of surface erosion and/or partial decomposition; compaction; and, in the case of bark, pod, and leaf fragments, distortion and curling. Partial distortion is common in material that is dried after being preserved in anaerobic environments. Specimens also usually retained traces of mud attached to their surfaces, penetrating the plant structures where breaks had formed. Thinner fragments (i.e. not the tough Canarium nutshell) were also quite brittle, breaking when flexed. The Canarium specimen taken from spit 14 as a representative of this group of archaeobotanical specimens dated to 5960 ± 44 14C BP or cal BP 6670–6900 (2σ) (Table 1, sample c). Preservation of betelnut and palm leaf specimens was quite different: both looked fresh, were flexible, and lacked obvious signs of ingrained dirt and staining (see Figure 1 for Areca specimen). On this basis, a possible modern source was suspected and confirmed for the betelnut husk by the AMS date, which returned a modern result (Table 1, sample d).

**DISCUSSION AND CONCLUSION**

AMS dating confirmed the suspicions, based on preservation condition, that the betelnut specimen is modern. Though the Areaceae-type leaf specimen was not directly dated, its preservation condition also suggests a modern provenance, and it was thus excluded from the ancient assemblage. While this evidence could be used to discount the antiquity of all associated archaeobotanical finds, we believe that this is not the case because of:

a. The obvious differences in preservation condition between the betelnut and palm leaf specimen and other specimens in the assemblage;

b. The direct Canarium nutshell date that corresponds closely with the previously published dates for the spits (11 and 27—see Table 1, samples b and e), which stratigraphically bracketed the samples considered here (Table 1; Figure 3).
Though there was clearly some modern contamination, the age of most of the Dongan assemblage cannot simply be dismissed as the result of intrusion of modern crop plants into ancient sediments. Neither can it be explained as an erroneous association of later material with “old wood” dates. The new date for *Canarium* was garnered from a fragment of the plant part actually used as food (the nut) produced in one growth season.

The obvious question arises of how modern plant material came to be found in archaeological strata. Were the specimens derived from reworking of the sediments by river action or from intrusion of modern plant material by some other mechanism into the strata? The fresh condition and lack of deeply ingrained sediment provide a clue. Dongan was a permanently wet site in which high groundwater levels and the sticky silt/clay sediments made excavation extremely difficult, especially in the lower deposits that extended beneath the river level (Swadling et al. 1988: Figures 35–37; Swadling et al. 1991: Figure 2). It seems unlikely that such fresh, clean plant material could have derived from material resident in the sediment body for a long period prior to the excavation, e.g. deriving from river reworking of sediments. A more likely explanation is that the modern specimens were incorporated into samples from the contemporary environment during excavation itself. The lower levels of the excavation trench filled with water every night. Water was clean and of potable quality, deriving from groundwater seepage rather than flooding from the river, and was collected by villagers for use in the kitchens (Swadling and Araho 1986:34). Visits by villagers to collect water for use in the kitchens and subsequent bailing before excavation provided ample opportunities for fragments of betelnut, commonly chewed by all, and sago leaves, commonly used

### Table 1 14C dates for fruit and nut samples from the Dongan midden in stratigraphic order.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Material</th>
<th>Spit</th>
<th>Method</th>
<th>Lab nr</th>
<th>Result</th>
<th>2-σ cal. age range</th>
</tr>
</thead>
<tbody>
<tr>
<td>a^3</td>
<td>Charcoal</td>
<td>4</td>
<td>Conv.</td>
<td>Beta-19075</td>
<td>5690 ± 170 14C BP</td>
<td>cal BP 6950–6000</td>
</tr>
<tr>
<td>b^3</td>
<td>Charcoal</td>
<td>11</td>
<td>Conv.</td>
<td>Beta-19076</td>
<td>5810 ± 80 14C BP</td>
<td>cal BP 6800–6410</td>
</tr>
<tr>
<td>c</td>
<td><em>Canarium</em> sp.</td>
<td>14</td>
<td>AMS</td>
<td>Wk-15724</td>
<td>5960 ± 44 14C BP</td>
<td>cal BP 6900–6670</td>
</tr>
<tr>
<td>d</td>
<td>Areca sp. husk</td>
<td>16</td>
<td>AMS</td>
<td>Wk-15725</td>
<td>119.3 ± 0.6 pM</td>
<td>MODERN</td>
</tr>
<tr>
<td>e^3</td>
<td>Charcoal</td>
<td>27</td>
<td>Conv.</td>
<td>Beta-19077</td>
<td>5830 ± 90 14C BP</td>
<td>cal BP 6860–6410</td>
</tr>
</tbody>
</table>

1 Conv. = conventional 14C date; AMS = accelerator mass spectrometry date.
2 Conventional age (14C BP) or percent Modern (pM) following Stuiver and Polach (1977); all dates calibrated using OxCal v 3.10 (Bronk Ramsey 2005).

![Figure 3](Atmospheric data from Bäumer et al. 2014, OxCal v 3.10; Bronk Ramsey 2005, calib 5sd 2 pM mod_front.png)

**Figure 3** Multiplot of calibrated 14C dates from the Dongan midden site (letters correspond to Table 1; calibration and plotting used OxCal v 3.10 [Bronk Ramsey 2005]).
in skirts, to be introduced to the site. Flooding and bailing left the upper surface of the excavation soft and would have allowed modern plant fragments to become trampled into the deposits for a short period of time before excavation, making them look superficially like genuine ancient specimens.

Archaeobotanical results show that the assemblage is less diverse than originally claimed, but the analysis confirms the use of a suite of possible tree-crop species in the tropical lowlands of New Guinea between 6 and 7 kyr BP. Possible pre-Lapita interaction with Southeast Asia based on this find cannot now be sustained, though regional and more local interactions as signified by other crop and artifact distributions remain open to debate and further investigation (Swadling and Hide, forthcoming; Denham 2004:613–5). Rather than regional interaction, the assemblage reflects the use of trees that were probably part of the native lowland New Guinea flora, and thus could be used to argue for insularity in food procurement traditions within either a food producing or gathering economy (see Fairbairn, forthcoming; Kennedy and Clarke 2004).

Analysis clearly confirmed the doubts expressed about the betelnut specimen’s antiquity (see Introduction) and removed a support for pre-Lapita crop movement from Southeast Asia to Oceania. It leaves betelnut specimens from Southeast Asia as the oldest on record (Yen 1977; Glover 1986), though some suspicion could be raised about the antiquity of the uncharred betelnut fragment from the north Thailand sites (Yen 1977: Tables 1 and 2) and both the age and identification of fragments from Timor (Glover 1986: Tables 130 and 131). A possible betelnut find in the pre-Lapita Halika occupation phase on Nissan, Papua New Guinea (Spriggs 1991:230) is the earliest in known Near Oceania, but its pre-Lapita status, as well as its identification, remains uncertain; hence, it should not be used as evidence of a pre-Lapita presence. Chemical analysis of stained teeth shows betelnut was chewed in Vietnam by 2 kyr BP (Oxenham et al. 2002) and the Mariana Islands at ~900 BP (Hocart and Fankhauser 1996). Untested staining on teeth suggests earlier betelnut use in Taiwan, and suggests Lapita contexts in the Bismarck Archipelago and the Philippines between 3 and 5 kyr BP (see Lichtenberk 1998:352–3), where betel’s presence has also been suggested on the basis of shell artifacts at 4630 ± 250 14C BP (Barretto-Tesoro 2003:304). Evidence for betelnut’s history is fragmentary and sometimes equivocal, but with the removal of the Dongan date, most is consistent with a Southeast Asian domestication for betelnut and subsequent spread from there to Oceania, probably at or after Lapita. However, evidence is so weak that a single well-provenanced archaeobotanical find could change the story completely.

In conclusion, this example shows that the presence of plant specimens in archaeological samples should not be used alone to evaluate the antiquity of individual finds or whole assemblages. The results suggest that careful archaeobotanical evaluation of specimen preservation condition can be a reliable and valuable indicator of specimen age and potential assemblage security. When combined with targeted AMS dating, these methods can refine our understanding of existing models of Oceanic crop history, and overcome some of the chronometric hygiene problems that have bedeviled archaeology in the region (Spriggs 2003).

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REFERENCES


