RADIOCARBON, Vol 47, Nr 3, 2005, p 377–382

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

Andrew Fairbairn[1] and Pamela Swadling

Department of Archaeology and Natural History, Research School of Pacific and Asian Studies, Coombs Building, Australian National University, Canberra, Australian Capital Territory 0200, Australia.

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 ^{14}C 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

[1]Corresponding author. Email: andrew.fairbairn@anu.edu.au.

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).

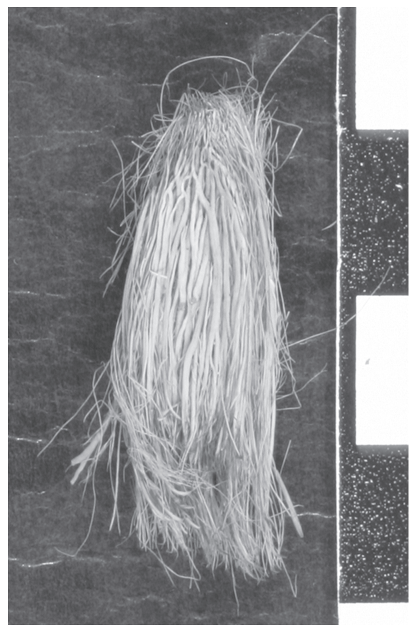

Figure 1 *Areca* sp. (betelnut) husk from Dongan Spit 16, dated by Wk-15725 (scale in cm; photo D O'Dea).

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 (Arecaceae) (Tomlinson 1961), but higher-level (e.g. genus, species) identification is not secure, hence the identification remains as "Arecaceae 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

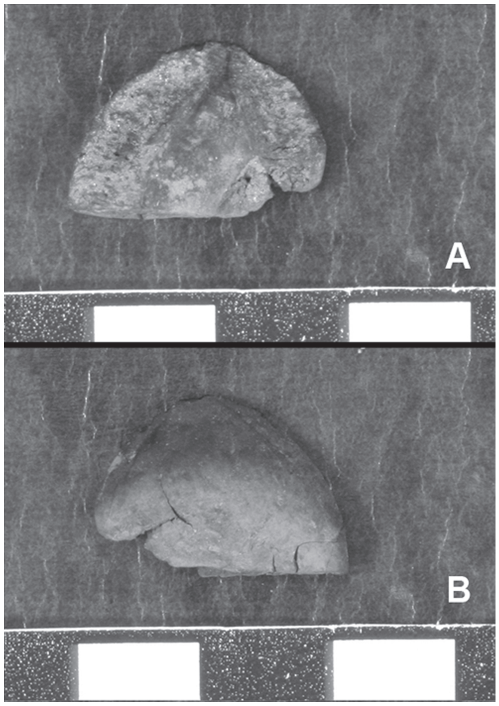

Figure 2 Section/inner surface (A) and outer surface (B) of *Canarium* sp. (galip) nutshell from Dongan Spit 14, dated by Wk-15724 (scale in cm; photo D O'Dea).

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 ^{14}C BP or cal BP 6670–6900 (2 σ) (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 Arecaceae-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).

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

Sample	Material	Spit	Method[1]	Lab nr	Result[2]	2-σ cal. age range
a[3]	Charcoal	4	Conv.	Beta-19075	5690 ± 170 ^{14}C BP	cal BP 6950–6000
b[3]	Charcoal	11	Conv.	Beta-19076	5810 ± 80 ^{14}C BP	cal BP 6800–6410
c	*Canarium* sp. nutshell	14	AMS	Wk-15724	5960 ± 44 ^{14}C BP	cal BP 6900–6670
d	*Areca* sp. husk	16	AMS	Wk-15725	119.3 ± 0.6 pM	MODERN
e[3]	Charcoal	27	Conv.	Beta-19077	5830 ± 90 ^{14}C BP	cal BP 6860–6410

[1]Conv. = conventional ^{14}C date; AMS = accelerator mass spectrometry date.
[2]Conventional age (^{14}C BP) or percent Modern (pM) following Stuiver and Polach (1977); all dates calibrated using OxCal v 3.10 (Bronk Ramsey 2005).
[3]Dates from Swadling et al. (1991).

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.

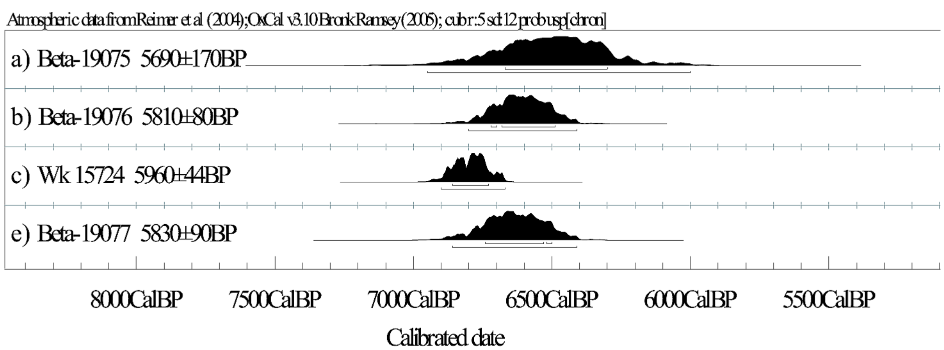

Figure 3 Multiplot of calibrated ^{14}C dates from the Dongan midden site (letters correspond to Table 1; calibration and plotting used OxCal v 3.10 [Bronk Ramsey 2005]).

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 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 ^{14}C 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).

ACKNOWLEDGMENTS

We acknowledge the pioneering archaeobotanical work of Douglas Yen, who first worked on the Dongan material and whose research directed our own; thanks to the National Museum and Art Gallery of Papua New Guinea for releasing the Dongan material; Waikato Radiocarbon Dating Laboratory for dating the samples; Jean Kennedy for valuable discussion and comments on a draft of this paper; and Dominique O'Dea from the Department of Archaeology and Natural History, RSPAS, ANU took the photographs used in Figures 1 and 2. Funding was provided by the Centre for Archaeological Research, ANU; the Department of Archaeology and Natural History, RSPAS, ANU; and the Australian Research Council.

REFERENCES

Barretto-Tesoro G. 2003. Burial goods in the Philippines: an attempt to quantify prestige values. *Southeast Asian Studies* 41:299–315.

Bronk Ramsey C. 2005. *OxCal Program v 3.10.* Oxford: University of Oxford Radiocarbon Unit. http://www.rlaha.ox.ac.uk/oxcal/oxcal.htm.

Denham T. 2004. The roots of agriculture and arboriculture in New Guinea: looking beyond Austronesian expansion, Neolithic packages and indigenous origins. *World Archaeology* 36:610–20.

Fairbairn A. Forthcoming. An archaeobotanical perspective on Holocene plant use practices in lowland northern New Guinea. *World Archaeology* 37(4).

Glover I. 1986. *Archaeology in Eastern Timor, 1966–67.* Terra Australis 11. Canberra: Australian National University. 241 p.

Hocart CH, Fankhauser B. 1996. Betelnut residues in archaeological samples of human teeth from the Mariana Islands. *Experientia* 52:281–5.

Kennedy J, Clarke W. 2004. Cultivated landscapes of the southwest Pacific. RMAP Working Papers 50. Canberra: Australian National University. http://rspas.anu.edu.au/papers/rmap/Wpapersrmap_wp50.pdf.

Kirch P. 1989. Second millennium BC arboriculture in Melanesia: archaeological evidence from the Mussau Islands. *Economic Botany* 43:225–40.

Litchenberk F. 1998. Did speakers of Proto Oceanic chew betel? *Journal of the Polynesian Society* 107: 335–63.

Oxenham MF, Locher C, Lan Cuong N, Kim Thuy N. 2002. Identification of *Areca catechu* (betelnut) residues on the dentitions of Bronze Age inhabitants of Nui Nap, northern Vietnam. *Journal of Archaeological Science* 29:909–15.

Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Bertrand C, Blackwell PG, Buck CE, Burr G, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Hughen KA, Kromer B, McCormac FG, Manning S, Bronk Ramsey C, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyhenmeyer CE. 2004. IntCal04 Terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* 46(3):1029–58.

Spriggs M. 1991. Nissan, the island in the middle: summary report on the excavations at the north end of the Solomons and the south end of the Bismarcks. In: Allen J, Gosden C, editors. *Report of the Lapita Homeland Project*. Canberra: Australian National University. p 222–43.

Spriggs M. 1996. What is Southeast Asian about Lapita? In: Akazawa T, Szathmary EJE, editors. *Prehistoric Mongoloid Dispersals*. Oxford: Oxford University Press. p 324–48.

Spriggs M. 2003. Chronology of the Neolithic transition in island Southeast Asia and the western Pacific: a view from 2003. *The Review of Archaeology* 24:57–80.

Stuiver M, Polach H. 1977. Discussion: reporting of ^{14}C data. *Radiocarbon* 19(3):355–63.

Swadling P, Araho N. 1986. Sepik-Ramu fieldtrip report, 21 Sept–29 Oct 1996 [unpublished report]. Port Moresby: National Museum.

Swadling P, Hauser Schäublin B, Gorecki P, Tiesler F. 1988. *The Sepik-Ramu: An Introduction*. Port Moresby: National Museum. 75 p.

Swadling P, Araho N, Ivuyo B. 1991. Settlements associated with the inland Sepik-Ramu Sea. In: Bellwood PS, editor. *Indo-Pacific Prehistory 1990. Vol. 2. Bulletin of the Indo-Pacific Prehistory Association 11.* Canberra and Jakarta: IPPA and Asosiasi Prehistorisi Indonesia. p 92–112.

Swadling P, Hide R. Forthcoming. Changing landscape and social interaction: looking at agricultural history from a Sepik-Ramu perspective. In: Pawley A, Attenborough R, Hide R, Golson J, editors. *Papuan Pasts: Investigations into the Cultural, Linguistic and Biological History of the Papuan-speaking Peoples.* Canberra: Pandanus.

Tomlinson PB. 1961. *Anatomy of the Monocotyledons. II Palmae*. Oxford: Clarendon Press. 344 p.

Yen D. 1977. Hoabinhian horticulture? The evidence and the questions from northwest Thailand. In: Allen J, Golson J, Jones R, editors. *Sunda and Sahul: Prehistoric Studies in Southeast Asia, Melanesia and Australia*. London: Academic Press. p 567–99.

Yen DE. 1993. The origins of subsistence agriculture in Oceania and the potentials for future tropical foods. *Economic Botany* 47:3–14.

Yen DH, McEldowney PH. 1991. Dongan plant identifications. Appendix to Swadling P, Araho N, Ivuyo B. 1991. Settlements associated with the inland Sepik-Ramu Sea. *Indo-Pacific Prehistory 1990. Vol. 2. Bulletin of the Indo-Pacific Prehistory Association 11*. Canberra and Jakarta: IPPA and Asosiasi Prehistorisi Indonesia. p 109–12.