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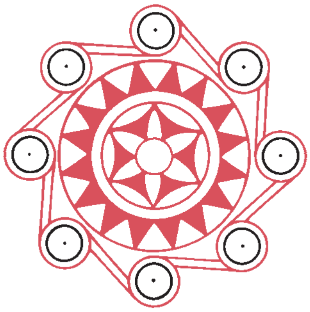

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ARTICLES

BOOK REVIEWS

Ritual, Landscapes of Exchange, and the Domestication of Canarium*: A Seram Case Study*

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Roy Ellen

ABSTRACT

It is widely accepted that a major historic pathway to agriculture in the tropics has been via the management of forest and reliance on tree resources. Using ethnographic and ethnobotanical data from Seram in the Moluccas, this article illustrates how this might have happened in one part of Island Southeast Asia. Several species of the genus *Canarium* produce proteinaceous nuts that have been ethnographically, historically, and prehistorically shown to be an important part of local diets. To understand how food-procurement systems evolve, we need to examine the biocultural dynamic established over the long term between different species, types of arboriculture, and cultivation strategies. One factor was likely subsistence pressure, but exchange has also been an important driver in relation to procurement of *Canarium* in particular and to the modification of forest landscapes more generally, hence the term "landscapes of exchange." While theorists tend to assume dietary need is the main cause of agricultural change, the social and ritual significance of particular species often drives ecological and genetic change in anthropic contexts. Keywords: domestication, arboriculture, landscapes of exchange, ritual selection, *Canarium*, Seram.

INTRODUCTION

A major pathway to food production in Southeast Asia and the Pacific has involved management of forest and reliance on tree resources. This understanding is driven by theoretical developments since the late 1960s drawing on ethnographic, ecological, and ethnobotanical approaches, helpfully synthesised in some of David Harris' (1966, 1973, 1977) seminal publications. Increasingly, the older transition to farming models, based on a process first recognized for European prehistory, have begun to look antiquated when applied to other regions. Models in which seed-cultures simply succeeded vege-culture have been questioned (Harris 1973:410–411) and the former firm distinctions between farmers and hunter-gatherers or foragers are now regarded as insufficient or misleading (Gosden 1995; Terrell et al. 2003). For example, the "Austronesian hypothesis" was propelled by converging linguistic and archaeological evidence of a rice-growing culture having migrated from Taiwan to the Pacific around 5000 B.P. As these Austronesians moved eastwards, however, they were seen to acquire tree crops and lose rice agriculture (Spriggs 2011; Yen 1985). Since an

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over-simplified dualistic model disguises the many ways subsistence strategies may combine and intertwine, Yen (1989) advocates a "domestication of environment" model in which the widest range of plant-food procurement strategies is examined in each particular location.

It is also no longer tenable to assume that forest changes taking place after the first humans arrived somewhere were always the outcomes of natural processes (e.g., as seen in Flenley 1979). Applying the distinctions of "wild" versus "domesticated" or "cultivated" to some plants is now seen as problematic, as are evolutionary schemes where domestication is only associated with the emergence of field agriculture (Harris 1996:441). More nuanced definitions of "cultivation," "domestication," and "management" have led to the recognition that plant food production might take place without domestication in the conventional sense (Harris 1989). Lively discussions have ensued around the idea of the tropical forest as a productive environment and the extent to which it can support human populations through foraging alone (Headland and Bailey 1991) and how to model the subsistence transition from forest foraging to gardening to explain the origins of agriculture in the Asia Pacific region (Groube 1989:301).

As part of these debates, especially those that involve attributing a significant prehistoric ancestry to tree management (Rabett 2012), the archaeological literature has highlighted the role of the proteinaceous nut genus *Canarium*. Here I focus on current and recent management of *Canarium* trees by Nuaulu on the island of Seram in the Indonesian province of Maluku, with some reference to nearby Ambon and the Ambonese, in part to reflect the important contribution of Rumphius (b. 1627–d. 1702) to the subject. The objective is to demonstrate the continuing role of *Canarium* for local people while providing some insight into what a comparable prehistoric system might have looked like and how *Canarium* arboriculture might have evolved ecologically and genetically.

The modern Nuaulu subsistence system in southern Seram is best described as "interstitial" (Ellen 1978, 1988). Today, the Nuaulu people are more devoted to farming than ever before, making swiddens, growing various vegetable crops, and increasingly tending large groves of cash crops as well. In addition to taro, yams, and cassava (the main staple of the swiddens), their principle source of starch was and continues to be sago from the palm *Metroxylon sagu*. Other plant products have long been extracted from local forests and managed to various degrees. In particular, the lowland forest displays "a higher than expected proportion of *Canarium*" (Edwards 1994:7). A mosaic forest is typical of many places with long histories of *Canarium* extraction (Matthews and Gosden 1997), especially where *C. indicum* constitutes part of traditional agroforestry (Nevenimo et al. 2007:123).

We thus have in Nuaulu a dynamic ecological system altered and maintained through human interventions which interconnect different subsistence strands (i.e., swiddening, hunting, plant gathering) in complex ways. While involving some interlocking sustainable cycles, this system has at the same time been subject to progressive change. Most significantly, the lowland forest has become what I call a "landscape of exchange" as useful tree species have been drawn into local, inter-island, and global trade in ways that have influenced the composition and evolution of the forest. Humans have selectively dispersed plant matter within the Sahul region for as long as they have lived there. Even low human population densities can have significant impacts, as the examples of *Canarium* and *Metroxylon* show. The development of characteristic maritime exchange networks focussed on trading with the sago-deficient small islands encouraged surplus production of sago in mainland areas (Ellen 1979; Latinis 2000). The landscapes of exchange entirely transformed the ecology of the small islands by encouraging clove and nutmeg production in the pre-colonial period, a process that accelerated in the early colonial period.

The ethnographic and ethnobotanical fieldwork forming the basis of this article was conducted between 1970 and 2015 among the Nuaulu people (population approximately 2000 in 1996) living in south central Seram (3°21′S, 129°08′E). The methods employed included producing annotated voucher specimens, participatory mapping, individual interviews, focus groups and, in 1996, 14 plot surveys. Plot surveys were undertaken in as wide a range of mixed forest as possible and in all areas with which the Nuaulu were actively interacting.

DIVERSITY OF THE GENUS *CANARIUM* ON SERAM

Canarium is a large genus of Burseraceae, a family found almost exclusively in the tropics of the Old World but uncommon in eastern Indonesia (Leenhouts 1959). Whitmore, Tantra, and Sutisna (1989) report four genera for Maluku, one being *Canarium*, the only genus known from Seram. *Canarium* is a large resinous tree with oily nuts; both the resin and oil are of interest to humans. The flowers are unisexual, which is significant for understanding the ethnobotany and process of domestication of this genus (Corner 1952:178).

The genus comprises 78 species worldwide (Weeks 2009). Nine species in Southeast Asia, Australia, and the Pacific have kernels regarded as edible: *decumanun*, *harveyi*, *hirsutum*, *indicum*, *kaniense*, *lamii*, *maluense*, *ovatum*, and *solomonense* (Nevenimo et al. 2007:119; my own field data). Recent research suggests ten species in the Moluccas, and for Seram we have accepted the following (with Leiden voucher numbers): *C. asperum*, *C. hirsutum* (26127), *C. decumanum* (25864), *C. indicum* (25899), *C. maluense* (1313, 4367, 4064), *C. sylvestre*, and *C. vulgare* (29 1986) (Table 1). *Canarium indicum* was not listed by Whitmore, Tantra, and Sutisna (1989), presumably

TABLE 1. SPECIES OF *CANARIUM* REPORTED FOR THE MOLUCCAS AND REGIONS NEARBY

SCIENTIFIC NAME	RANGE OUTSIDE THE MOLUCCAS
Canarium acutifolium (DC.) Merr.	Sulawesi, New Guinea, New Britain, New Ireland, Bougainville, Qld Australia
Canarium asperum Benth.	Java, Borneo, Philippines, Sulawesi, Sumbawa, Sumba, Flores, Timor, New Guinea, Solomons
Canarium balsamiferum Willd.	Sulawesi
Canarium decumanum Gaertn.	East Borneo, Sulawesi, New Guinea,
Canarium hirsutum Willd.	New Guinea, Solomons, Palau and throughout Malesia
Canarium indicum L.	Sulawesi, New Guinea, New Britain, New Ireland, Solomons, Vanuatu
Canarium maluense Lauterb.	Borneo, Sulawesi, New Guinea
Canarium oleosum (Lam.) Engl.	Sulawesi, Timor, New Guinea, New Britain
Canarium sylvestre Gaertn	New Guinea
Canarium vulgare Leenh.	Sulawesi, Flores, Timor

because they assumed it was a cultigen. While it may be true that it is strictly a cultigen, it is now indigenous to the Moluccas. We have to examine the relationship with all *Canarium* species to understand the process of domestication and associated historical ecology. We should also note that the description of *Canarium commune* by Linnaeus (following Rumphius) is from a mixed collection of specimens and refers to both *C. indicum* and *C. vulgare*. Thus, *C. commune* is used as a synonym for both species. *C. commune* is the same as *C. moluccanum* Blume and is also known as *C. amboinense* Hochr. The type of *C. commune* is *C. indicum*, but there are other elements in the original description of *C. commune* that are *C. vulgare* (Tim Utteridge, pers. comm. 2015). In this article, I use *C. indicum* for my Seram collections.

In any discussion of the evolution and diversity of *Canarium* in relation to human activity we must look below the species level, particularly in *Canarium indicum*, the most widespread species and firmly established as a domesticate. It is a large, fast-growing deciduous tree adapted to high rainfall; it reaches 40 m high and 1–1.5 m in diameter and buttresses are typical. The species is endemic to lowland Ambon and Seram, but occurs up to 600 m asl (Nevenimo et al. 2007; Verheij and Coronel 1992:322). Noting its whitish bark and oblong fruit, Rumphius (2011, vol. 2:215, 218) regarded this as the economically most important species in the Indies and called it the "common [*commune*] *kenari* [canari]," using the local Malay term. He made it very clear that this species did not grow wild but was instead found around the villages and "forest plots" (presumably swiddens) of Maluku (Rumphius 2011, vol. 2:218). The fruits of *C. indicum* are typically 60 × 30 mm and the tree is exceptional within the genus for tending to produce one large kernel in each stone rather than the usual three seeds seen in other species of the genus (Corner 1952:179) (Fig. 1).

Rumphius (2011, vol. 2: 215, 218) described the internal diversity of *C. indicum* and, following Ambonese folk nomenclature of the second half of the seventeenth century, distinguished four "races" based on the shape and size of the fruit: '*kenari besar*' (large kenari), '*kenari baggea*' (referring to a hard cake made from sago flour and kenari), and '*kenari kecil*' (small kenari), which was further subdivided into '*panjang*' (long) and '*pende*' (short).[1] '*Kenari besar*' fruit is large and oblong; '*kenari baggea*' fruit is round and difficult to shell; '*kenari kecil-panjang*' is small and oblong; and '*kenari kecil-pende*' is small and round.

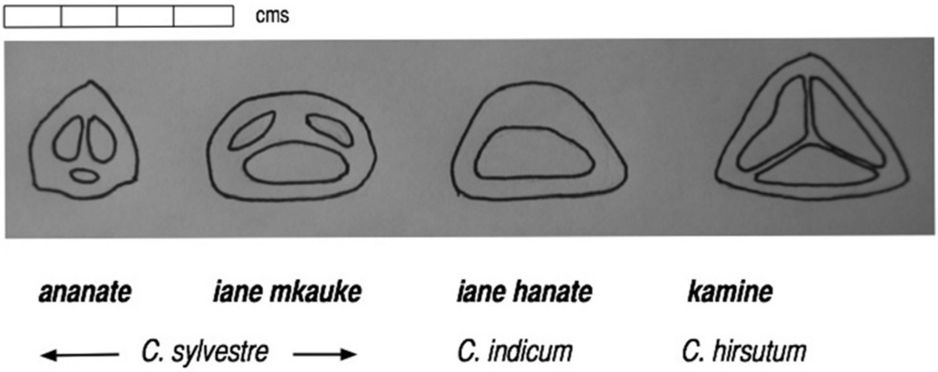

Fig. 1. Cross-section of mature fruits of selected species of *Canarium* showing placement of edible seeds in locules, with Nuaulu names and corresponding species names provided in Table 2.

All four varietals are described as having one locule (or chamber) filled with kernels, but occasionally there are two or more. By contrast, Rumphius describes *C. sylvestre* as having three small locules.

CANARIUM IN NUAULU ETHNOBOTANICAL CLASSIFICATION

Nuaulu people also distinguish different types of *Canarium* that they see as having a family resemblance (Table 2, Fig. 2). The generic local word for all *Canarium* is *iane* (henceforth referred to as *iane*-1). However, the term *iane* is polysemous and it also contrasts with another kind of '*kenari*' called *kamine* (i.e., *iane*-2), which includes *C. asperum*, *C. hirsutum*, and *C. decumanum*. *Kamine* is known as '*kenari* Seran' or '*damar putih*' (white resin) in Ambonese Malay and has a larger edible fruit than all the other folk-specifics of *iane*. The resin from under the bark at the base of the tree is used in lamps, though the resin from this species is said to yield less light than other types of *Canarium*. Its timber is used for building houses, but it has to be carried long distances because this species is located furthest away from Nuaulu village, a factor inhibiting systematic harvesting of nuts. A third but less extensive use of the term *iane* (*iane*-3) is to contrast with *ananate* (i.e., *C. sylvestre*), which has a smaller nut than *iane*-3. Although *ananate* is the source of an edible grub and resin from the trunk, it is seldom harvested because of its size. *Ananate* is thus recognized as a "kind of" *iane* but treated as a separate kind, depending on context of elicitation. Certainly, during the plot surveys in 1996, the *C. sylvestre* tree was always identified as *ananate* rather than *iane* and the uninomial was used as its default name. By contrast, *iane*-3 comprises two kinds of *Canarium* based on the shape and size of the fruit: *mkauke* (a small fruit containing three locules) and *hanate* (a large fruit usually containing one large locule). Confusingly—though representing a classic ethnobotanical problem—other names are used synonymously for these two folk taxa by those who are prohibited from using the main name: *yapono*, *haruku*, and *pukune* are used for *mkauke* and *nawe* and *kahiaue* for *hanate*. This plethora of terms suggests more culturally recognized diversity than actually exists. The third segregate of *iane*-3 is *iane hanaie*, which refers to *C. indicum* trees bearing only male flowers. Nuaulu recognize that some trees are hermaphroditic (dioecious) and others monoecious, so in using the term *hanaie* they are simply noting that such trees flower but do not fruit. Moreover, monoecy is expressed at different times of flowering of the sexes on the same tree, a variable characteristic encouraging cross-pollination and varietal instability (Maloney 1996:929; Yen 1985:323; Yen 1991). Fig. 1 shows cross-sections of the kernel for each of the folk-taxa from *ananate* (the smallest) through *mkauke* and *hanate* to *kamine* (the largest) and indicates the number and size of locules; the folk taxa are mapped on to scientific species. The most significant feature is that both *ananate* and *iane mkauke* are variants of *C. sylvestre*, while *mkauke* and *hanate* are different scientific species, but placed together in the folk classification.

Clues as to how Nuaulu see the relations between folk taxa are in the ways they use Ambonese Malay or Indonesian terms to describe their own flora. They use the Indonesian and Ambonese Malay term '*kenari*' to reference *Canarium* varieties other than *C. indicum* or even non-*Canarium* species. Thus, *ananate* is described as a kind of '*kenari*', which they distinguish from *C. indicum* by contextually adding the borrowed word '*nanari*', which Rumphius (2011, vol. 2:220, 228, 245) applied to various types of *Canarium* in different places (including the Bandanese landrace). In Maluku more

Table 2. Nuaulu Named Categories for Types of *iane*

NUAULU NAME	MEANING	SYNONYM	MEANING	SCIENTIFIC ID	NED VOUCHER NUMBER	CHARACTERISTICS OF FRUIT
ananate				*C. sylvestre*	BOGOR 15-91[a]	Non-edible, small
ia(ne) kauke, mkauke	k.o. cricket	*ia(ne) pukune*	'short'	*C. sylvestre*	BOGOR 15-05, 15-07	Edible, small
		yapono	toponym	*C.* probl. *sylvestre*	KEW 15-06	
		ia(ne) haruku	toponym	*C.* probl. *sylvestre*	UKC 15-137	
ia(ne) hanate	'west wind'	*ia(ne) nawe*	'long'	*C. indicum*	BOGOR 96-1006	Edible, large
				C. indicum	BOGOR 15-01, UKC 15-136	
ia(ne) hanaie	'male'			*C. indicum*	n/a	Male, no fruit
iane				*C. indicum*	BOGOR 15-99[b]	
kamine				*C. hirsutum*	BOGOR 96-1270[c]	Edible, hairy
				C. decumanum	UKC 96-1047c	Edible
				C. asperum	BOGOR 15-102	

[a] See also: BOGOR 96-192, 96-358, 96-359; KEW 96-359, 96-621, 96-193, 96-194, 15-92, 15-135; UKC 96-622, 96-360, 15-139.
[b] See also: BOGOR 96-935; KEW 96-936, 96-937, 96-892, 15-100, 15-101; UKC 96-1347.
[c] See also: BOGOR 96-1045; KEW 96-1046, 96-1271, 96-1272, 15-103, 15-104; UKC 96-1047a.

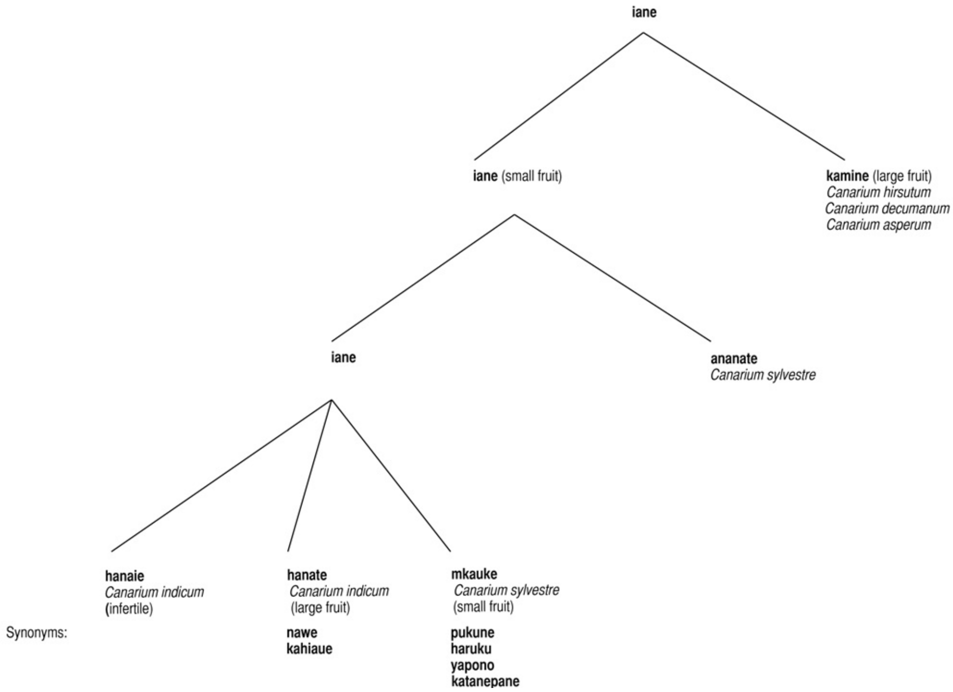

Fig. 2. Nuaulu folk classification for *Canarium*.

generally, the term '*kenari*' is applied to many species of *Canarium*, not just *C. indicum*. Interestingly, the Malay term '*kedongdong*' in its area of origin (presumably Riau and peninsular Malaysia) encompasses various species of *Canarium*, but not *C. indicum*, which was introduced there during the early modern period and is the only species described as '*kenari*' (see below). In the Moluccas, an area where Malay was initially the lingua franca, '*kedongdong*' was applied to edible fruits that superficially resemble *Canarium*, but are quite different phylogenetically. For example, '*kedongdong hutan*' (which the Nuaulu call *nihasa*) is *Spondius pinnata* (Anacardiaceae).

CANARIUM HARVESTING IN NUAULU SUBSISTENCE

The main Nuaulu use of *Canarium* is the edible nut. However, the resin of all species, which exudes from around the base of the trunk particularly in older trees, is regarded as valuable. *C. indicum* resin (called *kama iane*) is used for illumination (to fuel the '*damar*' torch) and as a firelighter, especially when working in the forest. The timber provides good firewood, but for construction is considered poor. *C. hirsutum* wood is brittle and perishable, but also may be used.

Canarium is undeniably an important food in the modern Nuaulu diet, but does not play a major role in everyday subsistence. Although consumed in large quantities, placing it third of forest foods by gram weight over a four month period in 1970–1971 (Ellen 1978:73), the amount consumed included days when feasts were taking place; *Canarium* nuts are not eaten at ordinary meals. A utilitarian dietary explanation for its high levels of production is therefore insufficient. Instead, *Canarium* production is driven by ritual demand, including its use in feasting, exchange, and ancestral offerings. *Canarium* is used at rituals for birth and death, male and female puberty rites, installations of elders with ceremonial barkcloth, and sacred house construction ceremonies.

Most nuts are collected from mature trees in the nearby forest. Timing and arrangements for collection depend on the season, quantity of fruit to be collected, and event to be provisioned. Trees flower at the beginning of the rainy season in May or June in south Seram and the fruits take between five and eight months to mature. Harvesting begins in the first three months of the dry season, October through December (Rumphius 2011, vol. 5:268n7; Verheij and Coronel 1992). Some trees bloom in September and ripen March through April; the so-called '*kenari barat*' (west *kenari*) is named after the western winds of this season. Fruits are either collected when green or when they have ripened to a blackish-purple. Fruits and leaves fall at the same time, roughly two months after maturation. At this time, humans compete with pigs to harvest the fruits before the pigs get to them.

The standard method for collecting is for one or more men to climb a selected tree early in the morning on a given day and knock down the fruits with a bush knife. Sometimes entire fruit-bearing panicles (which may comprise up to 30 fruits) may be removed, incidentally encouraging renewed growth and flowering (Nevenimo et al. 2007:119). Later the same day, usually late afternoon, women and children collect the fruits from under the canopy. Fruits are usually collected in a *pakune*, particularly a *paku sama-sama*, a narrow-necked, square-based, pot-shaped basket made of bamboo and rattan specifically designated for harvesting *Canarium* (Ellen 2009:254). Increasingly, polypropylene sacks or metal or plastic bowls are also employed. A collecting period of 1.5 hours will yield several hundred fruits (assuming an experienced collector), and a normal harvest from a single tree may exceed 1000 fruits. Fruits or extracted nuts may be transferred to larger carrying baskets to be taken to the village. Fallen fruits from trees growing on the village fringe are collected by women and children as part of the daily routine.

The fleshy pulp or mesocarp surrounding the nut is not generally removed at this stage, contrary to the practice described for commercial production (Nevenimo et al. 2007:124). Only small quantities of nuts are opened and the kernels extracted from source trees at the point of harvest; these are often eaten raw on the spot. Nuts are best for eating when picked early, though the testa (seed coat) must be removed for later processing as it causes diarrhoea. Because relatively few nuts are opened around forest trees, only the un-opened nut cases tend to be found as litter around the trees. The reason for this is that opened nuts do not store well and so entire fruits or nuts will be taken to the village and stored until they are required for a major feast, when further processing will begin.

Nuts are sun-dried on the ground, on racks, or smoked over a fire in the village, which dries the epidermis and pulp sufficiently to permit storage without further decomposition (Fig. 3). They are then stored (*mkauke* are generally regarded as having the best storage properties) in large tightly-woven shallow square-based baskets known as *nui matai* (Ellen 2009: fig. 7(h), fig. 10, fig. 11) or in sacks or they are piled loose in lofts or on racks above the house fire, as the kernels quickly go rancid once opened. Unopened nuts are stored for months, since it takes some time to accumulate the quantity required for a feast.

Preparing *Canarium* for a feast begins with opening each nut using anvils (*hatu unue*) and hammerstones or '*parang*s' (cleavers). Whether a stone or '*parang*' has been used is

Fig. 3. Mixture of *ia mkauke* and *ia hanate* on drying rack above house fire, Rouhua, 2015.

also likely to be clear in archaeological contexts. Hammerstones are considered preferable to using '*parang*' blades because the latter are prone to cut the kernel, although if the fruit is small the stone will crush the flesh. The anvils are usually found pieces of coralline limestone or schist, while hammerstones are preferably andesite or basalt, that is, stones of volcanic origin that may have travelled far from their source areas (Fig. 4). When a '*parang*' is used, a wooden block or half a coconut shell generally serves as an anvil (Fig. 5). Stone anvils (roughly 15 cm^2) generally have to be brought to the nut-breaking site from some distance and are rudely fashioned, if at all. Rumphius (2011, vol. 2:222) describes hammerstones and anvils as having small cavities that enable the shell to be effectively cracked while preserving the kernels whole (this feature is seen in Fig. 4b). Once positioned in the vicinity of a tree, forest shelter, or house, anvils often remain in place for decades; they are used by successive generations and for purposes other than breaking open *Canarium* nuts. When the tree dies or the house is vacated, the anvils are unlikely to be removed from the site. Therefore, wherever anvils are found archaeologically (at surface sites or in stratified excavation contexts) they are likely evidence not only of nut-cracking, but of the close proximity of living trees or houses in the past. Another characteristic of such sites is that a great deal of shell debris is left around the anvils. The hard pericarp surrounding the nuts survives well in archaeological contexts, though better when carbonised. Carbonisation provides further evidence of human association. Nut-cracking sites on the periphery of settlements may be associated with larger permanent anvils and enough shell debris may accumulate around such anvils to be archaeologically visible. Debris

Fig. 4. Anvil and hammerstones used for breaking nuts and associated debris, near Rouhua village, south Seram: (a) schist anvil found under a *Canarium indicum* tree, south Seram, February 1996 (left); (b) coralline limestone anvil on beach, August 1973 (right).

Fig. 5. Breaking open nuts using a '*parang*' and half coconut shell, Nuanea 2015 (photo by Emily Brennan, used with permission from Kopa Sounaue and Emily Brennan).

around smaller domestic anvils tends to be cleared away afterwards and would not be visible archaeologically.

Nut-cracking is laborious. Comparative studies suggest that one adult male can shell three sacks of nuts a day (Verheij and Coronel 1992:107), while Wissink (1996) reports 0.5–3.7 kg/hour for hand cracked nuts, with an average kernel yield of 1.2–2.7 kg per 20 kg. In the Solomons, 19–32 kg of nuts are reported as being processed per day, but it is acknowledged that the labour of nut-cracking constrains the expansion of commercial interest in the nut (Nevenimo et al. 2007:125).

Canarium is mainly consumed by Nuaulu in *maea* pancakes at feasts. Several thousand fruits, amounting to two or three large basket loads, are required to supply a feast. The *Canarium* most frequently used (and therefore stored) is *mkauke* (*C. sylvestre*) rather than *hanate*(*C. indicum*). *Ananate* (also *C. sylvestre*) is not used for *maea* as the small fruit is uneconomical to harvest given the distances that need to be travelled to the trees; despite the much larger fruit of the *kamine* (*C. decumanum* and *C. hirsutum*), it was formerly considered even less economical to harvest because of its location in distant forest.

To make *maea*, sago flour is dried, finely sieved, and mixed with ground *Canarium* nut. Once opened and the testa removed, kernels are smashed with a hammerstone on a wooden platter or crushed and ground on a flat stone using a wooden roller. The sago and crushed nuts are mixed with a little water to form a dough resembling marzipan, which is then rolled out into large flattened pancakes. A fire is prepared and the *maea is* cooked between layers of banana leaves and hot stones. It emerges as large flat sheets.

For a female puberty ceremony, *maea* sheets may be stacked high in baskets also containing sago biscuits and bananas. This basket of food (called *noi kakapai*) is paraded to the sacred house of the girl's father's clan, where the feeding of the neophyte will take place. Another confection known as *nesune* or *karatupa utue* is made by mixing *Canarium* flour with chilli peppers; it is wrapped in *Pandanus* leaves and cooked (Rumphius 2011, vol. 3:453). Making *maea* with peanuts instead of *Canarium* has become acceptable in some circumstances, though *Canarium* is still mandatory in ritual contexts. This innovation is an interesting reflection of how ritual requirements are modified to accommodate growing reluctance to invest in the labour required to harvest and process the nuts.

Nuaulu occasionally plant *Canarium* (usually *indicum*) in or on the edges of settlements from seedlings collected from around mature trees in more remote forest locations or grow them from seeds from places where the nut quality has been particularly appreciated (Ellen 1978:34). As present settlements expanded over time, some of these trees have become enclosed within the village area. Conversely, as villages have declined demographically or disappeared altogether, the useful trees are left to grow in the much modified secondary forest. More usually, *Canarium* is planted in gardens about two years after clearing, using seed from fruit-bearing trees that are regarded as having good content; they begin to fruit after 5–7 years. They may be deliberately planted in long fallow at a later stage and then left when clearing swiddens. Naturally-set seedlings in gardens or other frequented resource patches are physically protected and signified using markers declaring ownership and warning against unauthorised harvesting (Ellen 2016). In this way individual households and patrilines lay claim to ownership of groups of 20 or more trees.

Areas of distant forest with high concentrations of useful resources, including *Canarium,* may have taboos put on them protecting them from extraction and are only opened to provision major rituals. Ecologically-speaking, these clan *sin wesie* (protected areas) allow *Canarium* to reproduce naturally within a culturally protected space for the duration of prohibition, sometimes for as long as 15 years. Over the short-term, social access is through patrilineal inheritance and, in the longer term, through undifferentiated clan affiliation.

Canarium in the village or on the edges of the village or in old or fallow gardens adjacent current swiddens and groves is managed by cutting back undergrowth around trees. However, in more distant locations, mature trees merge into the forest, their anthropic origins disguised by large entwining lianas which assist harvesting by providing footholds.

Apart from deliberate management*,* there is evidence for *Canarium* being dispersed inadvertently, as fruits are transported from trees to the village in the process of harvesting and during processing. The mode of harvesting leaves fruits around trees under the canopy; missed by collectors, these fruits self-seed. Seedlings also grow from discarded food waste in the village or at forest camps. Elsewhere, clearance of forest patches for swiddens unrelated to *Canarium* aboriculture or of individual trees for timber provides the open gaps and sunlight that *Canarium* requires for germination and certain stages of growth. These factors increase asymmetric and anthropic features of *Canarium* distribution, including formation of patches, belts, strings of trees along trails, and concentrations in old settlement sites, in ways we would not expect through the natural dispersal of seed by bats or pigeons (Rumphius 2011, vol. 2:222). Similar patterns have been recorded for *Canarium* species elsewhere and for other proteinaceous nut species such as *Landolphia owariensis* (Ichikawa 1996). In such ways, human groups self-evidently construct their physical environment by creating resource patches through serendipitous seed dropping, selective extraction, and camp and trail-making.

Canarium is only planted in forest near existing settlements and swiddens, as seen in the *iane* in the 1996 plot 4 (old fallow) and plot 8 (depleted riparian forest) (Ellen 2007: table 3.4, fig. 3.2). Amatene (plot 10: 129°07′E, 03°19′S), an old clan village site above the Yana Ikine river at 400 m asl, five km northwest of the present village of Rouhua, is still visited on a regular basis for its *Canarium*. *Kamine* is found at the site itself and there is also a belt of *iane* at a lower altitude below the site between zones of bamboo scrub and depleted forest above long fallow gardens. This "belt" is a zone containing a higher density of *Canarium* than in any of the surveyed plots, though it still contains other tree species and rattan. The highest density of *Canarium* (7 out of 124 trees) is for the *ananate* in plot 7; this *sin wesie* or protected area conserves resources earmarked for major clan rituals.

Thus, there is some evidence supporting the claim that distribution of *Canarium* in Seramese lowland forests is influenced by human intervention, while management techniques provide a plausible explanation for how this might have occurred. Moreover, Nuaulu and other groups were more mobile before colonial interference in settlement patterns after 1880 and they occupied more dispersed and smaller clan hamlets. The effect of the earlier patterns would have been to spread *Canarium* and other useful trees more evenly throughout lowland rainforest and increase the number of higher density patches near the settlements.

CANARIUM IN SOUTHEAST ASIAN AND PACIFIC PREHISTORY

The earliest evidence for harvesting *Canarium* as a food-procurement strategy is the incipient transformation of forest by humans during the late Pleistocene and early Holocene, which suggests that they were inventing new and more complex food production systems. Recognizing the importance of nuts and seeds for the prehistoric peoples of New Guinea, Bulmer (1964) suggested a focus on arboreal resources. The breadth and depth of current evidence indicates that arboriculture was already sophisticated by the early Holocene (Stark and Latinis 1996). Rainforest archaeology is notoriously difficult, but human activity from about 50,000 B.P., including repeated biomass burning that interrupted ecological successions, is clear from the palynology, charcoal, and archaeology (Hunt and Rabett 2014:26; Maloney 1998). As early as 26,000 B.P. we have both artifactual and archaeobotanical evidence from the New Guinea highlands that cannot be simply interpreted as the aggregate consequence of casual extraction rather than deliberate management (Groube 1989:293–294; Summerhayes et al. 2010). An even clearer picture of systemic management in New Guinea is now emerging for the Holocene (Denham et al. 2003; Golson et al. 2017). In light of these studies and of what we know from historical and ethnographic sources concerning the blurring of the wild versus cultivated distinction (including for the specific case of Seram outlined above), it is wholly reasonable to envisage a continuum connecting domesticated with wild plants. The continuum would have involved long fallow swidden cycles and other kinds of forest biotope, burning, and translocation. These processes must have entailed a level of human impact on the forest that can be best understood as a cultural artifact (Barton et al. 2012; Latinis 2000:46), implicating behaviours consistent with a degree of familiarity, security, and control of the kind that Hunt and Rabett (2014:29) have called "management mentality."

While there are earlier pollen records (Maloney 1998:68), possibly the earliest macrofossil of large-fruited *Canarium* in a human context comes from New Britain at 14,000–6000 B.P. (Lentfer et al. 2013; Matthews and Gosden 1997). This would perhaps make *Canarium* the genus longest associated with humans in Melanesia (Yen 1996). For mainland Southeast Asia, we have *Canarium* seeds from Spirit Cave and other sites (i.e., Banyan Valley and Tham Pa Chan) in northwest Thailand between 11,000 and 4000 B.P.

(Gorman 1971; Reynolds 1992). The Spirit Cave seeds seem selected for larger kernels and were deliberately smashed, but they are similar to smaller, wild forms of *Canarium* found in Island Southeast Asia and Pacific sites (Yen 1977:571–574). *Canarium* remains at 11,000–8000 B.P. have been found in Vietnam (Viet 2008) and charred *Canarium hirsutum* (with possibly other species such as *C.* c.f. *odontophyllum*) is reported from Ille cave on Palawan at the Pleistocene/early Holocene boundary (11,000–9000 B.P.), suggesting regular use by people who were otherwise hunting and gathering (Barker et al. 2011:64–67; Lepofsky et al. 1998). There is prehistoric *Canarium* from Sulawesi (dated 11,000–3500 B.P.) (Paz 2004) and from Timor (Glover 1970).

Canarium harvesting was thus distributed across a wide arc by the mid-Holocene (Maloney 1998:68). Moving eastwards, *Canarium* is reported in Lapita sites throughout island Melanesia and New Guinea beginning 3000–6000 B.P. (Fredericksen et al. 1993; Lebot 1998; Yen 1993:8). *C. indicum* in particular has been important in Pacific diets since 6000 B.P. Lithic tools similar to those still used on Seram and diverse archaeobotanic remains in which *Canarium* is the most conspicuous genus together suggest *Canarium* arboriculture in the Philippines from 4000 B.P. (Latinis 1996). Matthews and Gosden (1997) report *C. indicum* at 4000–1000 B.P. as the most abundant plant remains in Arawe in west New Britain, while Lentfer and colleagues (2013) report a coralline limestone anvil with *C. ?indicum* residues at the same site linked to a Lapita date of 2800 B.P. Kirch (1989:229) reports *Canarium* in Lapita sites dated to 1300–500 B.C. at Mussau in the Bismarck Archipelago, where *Canarium* nuts were second only in frequency to coconut and showed evidence of having been opened with a hard hammer. *Canarium* is also reported from Eme cave in northeastern Luzon at 399-1690 B.P. (Paz and Carlos 2007).

The Moluccan data fit well with the emerging picture for Island Southeast Asia and Pacific prehistory as a whole. The earliest evidence for processing *Canarium* comes from the Tanjung Pinang shelter on Morotai in the form of a pre-ceramic anvil stone dated to 8860–3390 B.P. (Bellwood et al. 1993) and from carbonised *Canarium* from the Daeo 2 cave dated to 12,500 B.P. (Bellwood et al. 1998; Pasveer and Bellwood 2004:304). Not so early, but much richer, data have come from proto-historic sites on Ambon (Latinis 2002), with abundant *C. indicum* from the early levels (1100 A.D.) of the Batususu rockshelter (Stark and Latinis 1996:60–64). Both *C. indicum* and *C. lamii* are reported for the seventeenth century levels; the latter is now known only from the islands of New Guinea. *Canarium* was the dominant surviving food source in all layers throughout this period. Also found were large unmodified pounders made of limestone, granite, quartzite, or basalt; pounders including identifiable anvils and hammerstones constituted the main tool type. Thousands of anvils were found at the Tomu site alone (Latinis and Stark 2005), with evidence of processing at other sites (Latinis 2002:118). Some anvils display depressions consistent with Rumphius' (2011, vol. 2:222) descriptions and with the Nuaulu anvils described above.

All this evidence suggests continuous use of *Canarium* over a period of more than 1000 years at Ambon sites. *Canarium* most likely predated the importance of the Moluccan trade in clove and nutmeg and is consistent with the sago-fruit-nut arboricultural model Latinis and Stark (1998; Stark and Latinis, 1992) used to explain their data, which is in turn consistent with the historical ecology and ethnographic data presented in this article.

Finally, it is worth noting that Latinis and Stark (1998) point to similarities between *Aleurites moluccana* and *Canarium* processing, supported by Nuaulu ethnographic data.

A comparable pattern may be present with respect to *Terminalia catappa* ('*ketapang*') (Latinis, pers. comm. 2015). The distribution of *Aleurites* in Seramese forests is, like *Canarium,* suggestive of anthropic influence; contemporary ethnobotany is consistent with this interpretation. The co-occurrence of *Canarium* and *Aleurites* has been noted in the archaeological record at Spirit Cave (Gorman 1971; Yen 1977), Timor (Glover 1970), Mussau (Kirch 1989:234), Arawe (Matthews and Gosden 1997:124), and more generally (Bellwood 1997:235), suggesting links in forms of management and use. The co-occurrence of similar equipment and techniques shows how generic innovations cross over between different potential food species, something Bulmer (1964) had noted for mortars and pestles in the New Guinea highlands, such that tools are "pre-adapted" to later occurring circumstances.

CANARIUM IN MOLUCCAN AND ISLAND SOUTHEAST ASIAN HISTORY

There is a helpful chronological overlap between the evidence from Stark and Latinis' (1996) archaeological investigations and the earliest documentary evidence for *Canarium*. However, the earliest European records seldom mention *Canarium* for the Moluccas (though see Galvão [1971:46–49], and Nowell [1962:226, 240, 245] on Pigafetta). As Stark and Latinis (1996:63) specifically note, *Canarium* is almost never mentioned in historical sources describing the Moluccan spice trade. In the mid-eighteenth century, Rumphius provided the first extended European description of *Canarium*; he listed 12 "species" for the Moluccas, including the most important *C. indicum* (the only one he regards as a domesticate), which he divided into four "races" (Rumphius 2011, vol. 2:215, 218). In Rumphius' time, *C. indicum* was more or less restricted to the Moluccas, although it had recently been introduced to Java through the spice trade (Rumphius 2011, vol. 2:220). During the Dutch period, *C. indicum* spread throughout Island Southeast Asia as far as the Malay peninsula. Crawfurd (2013 [1820]: 383) picks up on the significant distribution of *C. indicum* east of what we would now describe as the Wallace line and discusses the biocultural mutualism between *Canarium* and sago in the Moluccas, which, with the expansion of the clove and nutmeg trade from the sixteenth century, provided resilience to the subsistence system of the Moluccas (Ellen 1979).

From an economic standpoint, there are two kinds of *Canarium* fruit: those suitable as "nuts" and those suitable as "olives" (i.e., the surrounding flesh). *Canarium* also yields two kinds of oil: elemis and dammars. In colonial Ambon, mainly *C. indicum* was used for food in the form of nuts, but also for oil, medicine, timber, and resin (particularly from *C. oleosum*) for torches and caulking boats (it is still used today for the last purpose) (Burkill 1935:426). In Banda, *Canarium* are important for shading nutmeg and were deliberately planted by the Dutch for this purpose (Wallace 1962 [1869]:221).

In looking at the distribution and use of *Canarium* during the colonial period, we can usefully examine the case of the Malay peninsula. *Canarium* olives are more often used in association with the '*kedongdongs*' in the western archipelago. The Malay term '*kedongdong*' is still used in peninsular Malaya for endemic wild species of *Canarium* having smaller fruits (Burkill 1935:425), as well as for Meliaceae tree species. The salience of '*kedongdong*' is reflected in Corner's (1952:177) description of Burseraceae as the "*kedongdong*" family. These fruits were used both for nuts and olives before the arrival of *C. indicum* from the Moluccas, perhaps in the seventeenth century. Thus, we have a case of an indigenous Moluccan species moving into the historical Malay language area but not interbreeding with local *Canarium*.

Rumphius (2011, vol. 2:220, 245) draws attention to the importance of the oil, particularly '*nanari*', that is, the Bandanese landrace of *C. indicum*. He regarded '*nanari*' as less greasy than coconut oil and therefore more suitable for cooking. '*Nanari*' was mainly used for pressing oil. The two smaller Rumphian varietals of what he called "common *kenari*," that is '*kenari panjang*' and '*kenari pende*', were also considered best for pressing oil (Rumphius 2011, vol. 2:219). Crawfurd (2013 [1820]:383) thought '*kenari*' oil was the finest available. Although its use has declined due to the availability and lower production costs of coconut oil, '*kenari*' oil is still produced in some localities. The best oil comes from nuts left to ripen on the tree. On Banda, this oil was produced in large quantities in the middle of the nineteenth century and today is still used to pickle tuna, for example (Ellen 1992:126). It is possible that Nuaulu people who lived in mountain settlements previously extracted the oil, but they no longer do so. Oil extraction could only have followed the innovation of suitable presses.

The distribution of the Ambonese term '*kanari*' or '*kenari*' (for referring to *C. indicum*) indicates the tree was cultivated in Island Southeast Asia, westwards to Java and beyond, both in the pre-colonial and colonial periods (Burkill 1935:425–426). As noted above, *C. indicum* was seldom referred to in colonial reports about the Moluccas, at least compared with current literature on its potential in Melanesia for commercial extraction or for the potential of *C. ovatum* (*pili* nut) in the Philippines (Verheij and Coronel 1992:105–107). There are no references to *Canarium* in Polman's (1982) annotated bibliography, while many other trees of commercial significance, such as *Agathis alba* (for resin) or the eucalypt *Melaleuca leucodendron* (for medicinal oil), are indexed. With the conspicuous exception of Rumphius' work, the lack of historical record suggests that the production and circulation of *Canarium* was of less interest to the colonial exchange economy than to local people. Though *C. indicum* retains residual culinary uses and is an occasional famine food and a commodity in the cultural tourism industry, its overall significance has declined in the modern period.

While *Canarium* nuts are a high value product, the value resides in the harvesting and processing costs, not in the rarity of the tree. As we have seen, the species is common in lowland forest, sufficiently so for it to be cut for timber by Nuaulu people. Such a casual approach suggests that there are sufficient trees to meet food demands and that decline in the harvesting and cultural importance of *Canarium* elsewhere in the central Moluccas, combined with a wood shortage for marine construction, may explain why its timber is used widely for canoes and other purposes despite its relatively indifferent qualities (Ellen 1985:579–581). With the spread of permanent cash-cropping, *Canarium* is being increasingly logged-out (Monk et al. 1997:729).

DISCUSSION

Ritual Selection and Production for Exchange

When archaeologists come across *Canarium* in any quantity during excavations, the understandable explanation is that it must have been a valuable source of protein and a significant element in the general diet. Indeed, *C. indicum* nuts are 72 percent fat and 13.5 protein (Burkill 1935:429). Recent data confirm the protein content but indicate variations between species (Nevenimo et al. 2007:120). However, as mentioned above, the costs of harvesting and processing are high. A common cause of Nuaulu male injury and death is falling from high *Canarium* trees, a misfortune so culturally salient as to be marked by recognising it as a distinct form of "bad death" (*kamanahune*); those who have thus died undergo special mortuary arrangements and the bad death is further marked by a distinctive type of malign spirit. Compared with the costs and risks associated with hunting animals (Ellen 1996), however, the reliability of *Canarium* as a food source might be thought advantageous and the overall labour cost more adaptive in environments associated with greater nutritional pressures (e.g., the northeast Australian rainforest) (Harris 2006:84–88).

In the case of the Moluccas, however, there is a further issue: *Canarium* might not be a daily subsistence item at all. In modern Ambonese and central Moluccan food culture, *bagea* is a festive snack made of equal amounts of sago and '*kenari*' and eaten on special occasions. Amongst Nuaulu, it is a feasting food, a food to be exchanged, and a food only seriously consumed in ritual contexts. Indeed, the costs of processing are too time-consuming to justify any other explanation. The large-scale processing reported by Stark and Latinis (1996) for Batususu suggests a specialized processing site rather than an occupation site, perhaps related to the role of *Canarium* as an exchange crop, either raw or as *bagea*, and to a significant trade in the commodity (Latinis pers. comm. 2018). Dense deposits of burned *Canarium* shells were also found at Batususu, which suggest a further use as fuel (also reported by Rumphius 2011, vol. 2:222), rather than simply the unused residues of the drying process.

By contrast, the Nuaulu ethnographic evidence for limited processing around trees and with a main focus in the villages suggests a different pattern. Nuaulu food intake studies conducted in 1970 and 1971 barely registered *Canarium*. It constituted only 0.2 percent of forest-gathered plant foods. Only 0.9 grams of *Canarium* was consumed per person per day over a four-month period, yielding only 0.53 grams of fat and 0.18 grams of protein per person per day (Ellen 1978:70–73). By comparison, bamboo shoots contributed 2.3 percent of forest-gathered plant protein and even sago 1.5 grams of protein per person per day because of the relatively large quantities consumed. Compared to animal protein, *Canarium* contributed a little more than snakes, civet, crab, prawns, bats, or birds (0.13 or less grams).

The diet diary self-reports incorporating feasts showed that *Canarium* consumption peaked around festival times, plus small residues left over from the feasts were consumed at everyday meals. Significantly, after Nuaulu individuals convert to Christianity or Islam, they rarely gather *Canarium* and no longer take an active role in its management, since the feasts that required *Canarium* are no longer hosted. For this reason, we might reasonably assume that the main motive for harvesting and managing *Canarium* was to facilitate an economy of ritual exchange and consumption for earlier populations, too.

Thus, to explain its present abundance in the lowland forests of Seram and elsewhere, plus the asymmetries in its distribution, I am arguing that managing *Canarium* was likely motivated by ritual rather than nutritional pressures. *Canarium* is ritually important in other parts of the southwest Pacific; for example, it is a measure of wealth and a medium of exchange in the Solomons (Hviding and Bayliss-Smith 2000; McClatchey et al. 2006). Why these nuts in particular were selected as a ritual food must be partly due to the difficulties in harvesting and processing them. Evidence for the role of ritual in the selection of other food plants and characteristics is found elsewhere in Southeast Asia. For example, the glutinousness of rice and other grains is ritually significant (Sakamoto 1996). It is also significant that *Canarium* is a waxy, concentrated source of fat that complements the basic starch staple of sago.

Theorising Canarium Domestication

David Harris (1977:fig. 3) proposed a model for a wild tree-nut harvesting system that falls short of domestication in the sense hitherto understood by plant scientists and archaeologists. I propose that the initial phase of *Canarium* use involved opportunistic gathering of fallen nuts from various species, probably alongside other nut-producing genera such as *Aleurites*, perhaps copying the harvesting of nuts by pigs and certain bird species. However, production could be increased by climbing trees and collecting nuts before they fell, thus avoiding loss through predatory competition with pigs. The early processing stages (collection, drying, and transport of whole fruits to settlement sites) would have provided opportunities for inadvertent loss and consequently for the redistribution of trees in patterns that serendipitously made them more useful. Later, fruits and seedlings could be deliberately protected and planted in areas that made them more useful, as we see in contemporary Nuaulu aboriculture.

Although there are hermaphroditic trees in any population of *C. indicum,* effective pollination requires male trees (called *iane hanaie* in Nuaulu). The gene flow that would register as evidence of domestication would be where large numbers of trees grow in proximity (Nevenimo et al. 2007:119). Repetition of these processes over several thousand years would likely lead to the spatial distribution of preferred species and varieties within species in ways that made them more useful and susceptible to further selection from those trees with the preferred qualities such as a single large locule rather than multiple locules in the nut, multiple seeds in the main locule, a profusion of fruit, larger fruits and nuts, thin pericarp, improved taste, and high oil content. However, the kernel to nut ratio was probably the most important single criterion for selection (Nevenimo et al. 2007).

Yen (1977:574) notes that early *Canarium* from northwest Thailand is tri-locular rather than mono-locular, though there is evidence of selection for the single locule in the Pacific forms (Yen 1974). Kirch (1989:231) found at Mussau that two of the three locules were much reduced. He compared modern and archaeological *C. indicum* on Mussau and was able to show that modern nuts were much larger. Kirch (1989:fig. 8) also suggests that the large size and length of modern Bandanese *C. indicum* fruits indicate a long period of selection. Matthews and Gosden (1997), on the other hand, report that *C. indicum* at Arawe showed no discernible size differences in the fruit at different periods, so they are more skeptical in their interpretation of early evidence for domestication and human use. Nevertheless, nut size in useful *Canarium* species has increased over time (Lepofsky et al. 1998) and is possibly even reflected in genetic modification during the early and mid-Holocene (Barker and Janowski 2011:10; Smith 1995). In this way, particular species, particular varieties of those species, and individual trees would likely be selected over others, creating more intra-specific and local diversity. It is therefore counter-intuitive that Nuaulu *mkauke* (*C. sylvestre*) continue to be prevalent, when from a consumption angle the larger-loculed *hanate* (*C. indicum*) is more economical. Possibly, male flowers from *mkauke* trees are cross-pollinating with *hanate* trees, maintaining the small-loculed varieties in the gene pool.

Note that different species are preferentially harvested and that the range of species varies in different parts of the *Canarium* distribution (Yen 1991:82–83). *C. indicum* has the widest prehistoric distribution from the Moluccas eastwards to Vanuatu. It is identifiable in Pleistocene deposits, so it is unlikely that human interaction contributed to its speciation as opposed to its sub-specific diversity. *C. ovatum* (the *pili* nut) in the Philippines varies from place to place and we also have good evidence for the cultural selection of *C. harveyi* in Santa Cruz, the Polynesian outliers, and the Banks Islands in the Solomons (Yen 1974, 1985), where it seems to replace *C. indicum* as the most important domesticated type. *C. decumanum* is significant as a domesticate on Manus along the northern coast of Papua westwards into the Bird's Head (Yen 1991:82) and, as we have seen, is also significant for Nuaulu. We find different subspecies of *C. indicum* in different parts of its distribution; for example, *C. i. platyceriodium*, with its larger fruits and leaves, is found in New Guinea (Verheij and Coronel 1992:323). *C. solomonense*, extracted wild, is much more localized and two distinct subspecies are used mainly in New Guinea and the Solomons (Yen 1985:320). More fieldwork and herbarium research should identify other subspecies in other parts of the range.

This pattern of geographic variation is consistent with claims for the domestication of various species at multiple sites in the early Holocene of Island Southeast Asia and Melanesia (Hunt and Rabett 2014:27), as well as for human-assisted circulation of germplasm over a wide area. The emerging picture of dynamic local and recent movement and selection in the eastern part of the *C. indicum* range suggests the implausibility of distinguishing wild from cultivated forms taxonomically (Yen 1985:321, 323). Yen (1985) suggests for example that as *C. indicum* moved eastwards, it either became feral or wild forms moved into new habitats and were domesticated locally.

Gepts (2014:52) proposes a linear model for *Canarium* domestication. Stage 1 comprises pre-domestication divergence from other wild types; stage 2 human awareness of resource and gathering (into which the *C. indicum* evidence for inadvertent selection would fit); stage 3, translocation and cultivation, such as by transplanting *Canarium* seedlings to village peripheries; stage 4, the appearance of hereditable changes (which would intensify during preceding phases); stage 5, dispersal from centres of diversification; and stage 6, further selection and local adaptation. However, since local *Canarium* populations can clearly survive without human intervention, they would not come under the category of "advanced domestication" (2014:52). Furthermore, this model lacks feedback; we need to take into account the complexity of gene networks as germplasm moved between numerous areas of simultaneous local domestication, in line with Vavilov's law of homologous variation (Kupzow 1975).

Local domestication is characterised by a reduction in genetic diversity due to drift and selection (Gepts 2014:51–53), though this is probably less apparent for fruit and nut trees than for grains and would be hindered in part by continued gene-flow between wild and domesticated forms where domestication was ecologically viable. We see this in the cross-pollination of different sub-specific populations of Nuaulu *C. sylvestre* trees. At the same time, wherever a *Canarium* species is under serious selective pressure and systematically used, we would expect intra-specific phenotypic diversity. Thus, Rumphius (2011) identified four varieties of *C. indicum* in seventeenth century Ambon and I have identified two folk-varieties of *C. sylvestre* in Nuaulu based on ethnographic evidence. Yen (1974) has identified five different large fruit forms of *C. harveyi* in the Solomons.

The dynamics of *Canarium* domestication are distinct in a number of other ways. Selection is entirely sexual, in contrast to the clonal selection Nuaulu are familiar with for sago, for example, where phenotypic differences can be intensified over a relatively short period, but are not genetically stable. Looking simply at sexual selection, *Canarium*, despite being a fast-growing tree, manifests the genetic consequences of selection more slowly, fruiting only after five to seven years. Humans require an intergenerational perspective to select the traits they want in *Canarium* (Denham 2011), compared say with rice, where selection can be monitored and adjusted every season. *Canarium* aboriculture thus cannot be thought of in the same way as grain domestication.

Finally, we should note the implications for phylogeny. For the arc of distribution between the Philippines and the Solomons, Yen (1991:85) identifies a Western "vulgare" group (including *C. indicum*, *C. ovatum*, and *C. vulgare*) and an Eastern "maluense" group (including *C. lamii*, *C. solomonense*, and *C. harveyi*). However, using data from 16 *Canarium* species, Weeks (2009:778) reconstructs three taxonomic sections of the genus using DNA sequences from seven chromosomal regions: *C. decumanum*, *C. harveyi*, *C. indicum*, *C. ovatum*, and *C. vulgare* (Fig. 6). While different

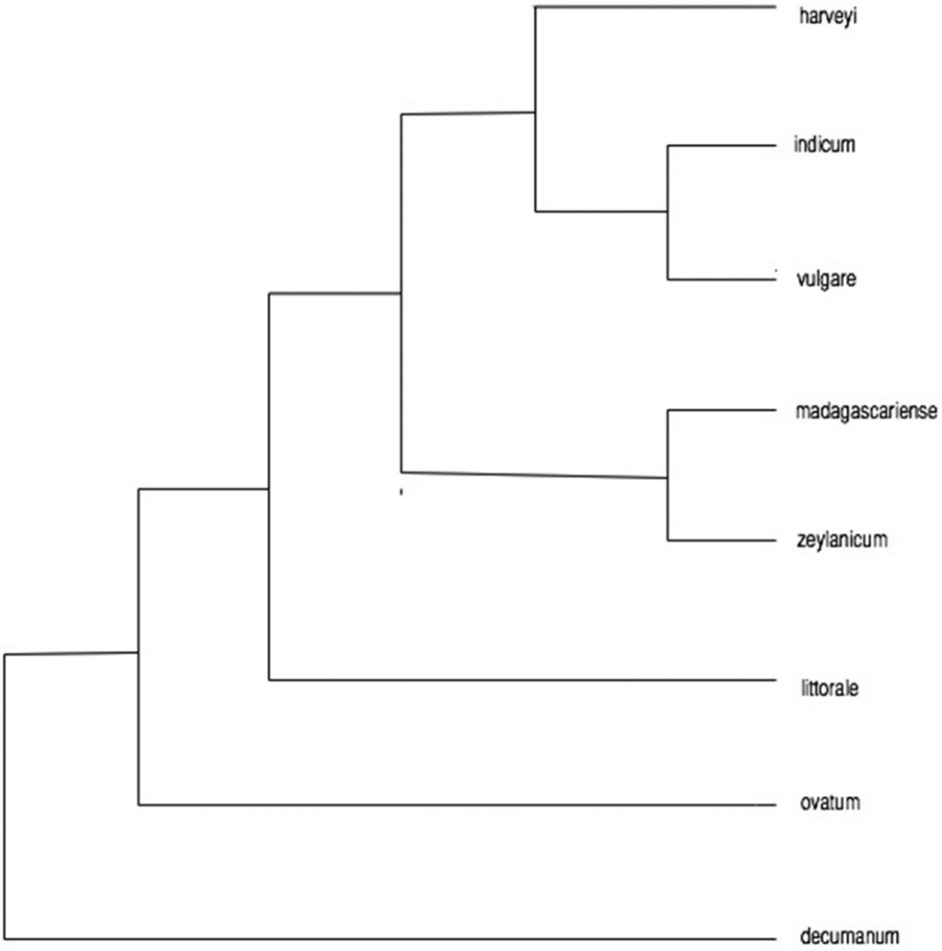

Fig. 6. Simplified representation of clade based on nrDNA ETS sequences, conforming to *Canarium* section genus *Canarium* (after Weeks 2009).

from Yen's morphological grouping, both results indicate that *Canarium* comprises at least two distantly related evolutionary lineages, desirable fruit characteristics of cultivated and wild-harvested edible species having evolved multiple times. In other words, as a genus, *Canarium* is polyphyletic rather than monophyletic. Characteristics useful for edible nuts and cultivated species are dispersed throughout the phylogeny, a pattern consistent with ethnobotanical and archaeological evidence.

SUMMARY AND CONCLUSION

Moluccan data illustrate the dangers of assuming short histories of anthropic interference and the importance of placing landscape in the context of regional histories of exchange. The emerging archaeological picture for early domestication of *Canarium* is connected in this article with a detailed empirical study of its ethnobotany and ethnography in a particular place. I argue that resource processing leaves some potentially strong archaeological signatures, but these must be interpreted carefully, since the ethnographic evidence is sometimes counterintuitive. In addition, a hypothesis for *Canarium* domestication and intensification of extraction is offered as part of a "multi-dimensional model" (Denham 2011). The evidence points to *Canarium* arboriculture stretching back well into the Pleistocene. While the spatial and temporal distribution of evidence for harvesting *Canarium* suggest that in general terms basic nutrition must have been a significant early driver of its increasing importance, some features of its management might better be explained in terms of its role in provisioning ritual rather than subsistence. Hunt and Rabett (2014:30) have questioned whether true domestication (morphological and behavioural change) actually took place in Holocene forest systems, but the case of *Canarium* suggests that it did. However, it is probably a mistake to focus too narrowly on a single species, form of arboriculture, or management strategy in explaining the process.

The data presented here suggest that *Canarium* harvesting preceded the development of field agriculture of grains or tubers, but once field agriculture arrived in the Moluccas (ca. 3000 B.P.) along with Austronesian-speaking farmers, *Canarium* harvesting became part of a system in which long swidden fallows intensified the diversity and management of useful trees. I am not arguing that intensive cultivation of grains or roots arose directly from arboriculture, only that arboriculture preceded it and has to be discussed in relation to it (e.g., to understand the management of long fallows). I am persuaded, however, that *Homo sapiens* has actively been managing tree resources in the region since 50,000 B.C. and that this management entailed a very clear understanding of plant reproductive processes.

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NOTE

1. Inverted commas have been set around Ambonese Malay or Indonesian words to distinguish them from Nuaulu terms throughout the article.

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