Indigenous edible nuts in Papua New Guinea

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Abstract

This paper describes some of the indigenous edible nut species of Papua New Guinea (PNG), that is, species which were grown and eaten prior to settlement by other Pacific Islanders, Europeans and Asians from about 1870 AD onwards. More than 40 species of indigenous nuts are eaten in PNG. Information is given here on 13 of the most commonly eaten indigenous nuts, which are grown by 2% or more of the rural population, and three other indigenous nut species. The following attributes are covered for each species: how the nut is consumed; global distribution; distribution within PNG; altitudinal range in PNG; production pattern (crop seasonality); the number of rural people who live in locations where the species is commonly consumed; marketing; and potential for further development.

The species covered are breadfruit (*Artocarpus altilis*), candle nut (*Aleurites moluccana*), castanopsis (*Castanopsis acuminatissima*), *dausia* (*Terminalia megalocarpa*), finschia (*Finschia chloroxantha*), *galip* (*Canarium indicum*), *karuka* (*Pandanus julianettii*), wild *karuka* (*Pandanus antaresensis and P. brosimos*), *okari* (*Terminalia impediens* and *T. kaernbachii*), *pao* (*Barringtonia procera*), Polynesian chestnut (*aila*) (*Inocarpus fagifer*), sea almond (*talis*) (*Terminalia catappa*), *sis* or *solomon* (*Pangium edule*) and *tulip* (*Gnetum gnemon*). Notes are given on three minor introduced species – macadamia, cashew and pecan.

Introduction

Indigenous edible nuts are defined here as species that were grown and eaten by Papua New Guineans prior to settlement by other Pacific Islanders, Europeans and Asians from about 1870 AD onwards. The species include nuts that are endemic, native, or introductions from other locations prior to 1870 AD. The term nut is used in a popular sense, not a botanical one. A list of more than 40 species of indigenous nuts that are eaten in PNG is given in Bourke (1996). Other papers that cover more than one species include Powell (1976:Table 3.1), Henty (1982), French (1986), Evans (1996a, 1996b), Yen (1996), and Walter and Sam (2002) (Table 1).[1]

Information is given here on 13 of the most commonly eaten indigenous nuts in PNG, and three other indigenous species. Those 13 species were selected as they are grown by 2% or more of the rural population (Table 3). The other three species (candle nut, finschia and *Pandanus antaresensis*) were included as they are minor foods in a few locations. Two important nut species, coconut and peanut (an introduced species), are not considered here.

All of the commonly grown edible nuts are indigenous (Table 3). A number of edible nut species have been introduced to PNG over the past 130 years but have failed to bear or bear poorly and have not been adopted by villagers. These species include almond, chestnut, hazelnut, pecan and walnut (French 1986). Macadamia (*Macadamia integrifolia* and *M. tetraphylla*) has been introduced from Australia. There are plantings on research stations or agricultural colleges, for example, at Aiyura, Karimui, Kuk, Laloki and Popondetta. Macadamia has never been adopted by villagers as a food in PNG. I have only seen trees in villages on two locations; on Karkar Island, Madang Province (where they did not bear) and in a village in the Lai Valley in Enga Province. Macadamia bears from sea level to a mean altitude of 1750 m, and occasionally up to 1810 m (Table 5). The best trees are at Karimui station (1140 m), where both species bear reasonably well.

Another introduced nut species that is sometimes grown is cashew. There are a few trees on agricultural stations, other government stations and in villages in the lowlands, including near Aitape, Amanab and Lumi in Sandaun Province, the Gazelle Peninsula in East New Britain Province, the Ramu Valley in Madang Province, and at Bulolo and Wau in Morobe Province. The highest bearing trees were at 1400 m in the Benabena Valley in Eastern Highlands Province. There was a plot on Numa Numa Plantation in north-east Bougainville (Allen 1991). There are larger plantings at Lanakaulana Plantation in Central Province, intended for the export market. Trees seem to bear quite well both at locations that experience a dryer period each year, but also at locations where rainfall is fairly even throughout the year. At the PNG Fruits and Nuts 2005 Workshop, it was reported that some villagers have been roasting nuts for local sale. Pecan nut (*Carya illinoensis*) has been introduced to PNG and several bearing trees have been noted growing at 1400–1600 m on a plantation and a research station (Aiyura) in Eastern Highlands Province.

Where available, information is given on the following attributes for each species: how the nut is consumed; global distribution; distribution within PNG; altitudinal range in PNG; production pattern (crop seasonality); the number of rural people who live in locations where the species is commonly consumed,[2] marketing; and potential for further development. The

[1] References to tables and figures in this paper are to those in the paper 'An overview of edible fruit and nuts in Papua New Guinea' in this volume.
[2] Population figures are derived from the 2000 census data, with a total rural village population of 4.2 million people.

distribution data is from the Mapping Agricultural Systems of PNG (MASP) database (Bourke et al. 1998) and the author's field observations. Data on crop altitudinal range is from Bourke (1989) (Table 5), and that on production patterns is from Bourke et al. (2004). The figures for the number of people who grow each species is from the MASP database (Table 3). I use the term New Guinea to refer to the island and Papua New Guinea (PNG) to the state.

Sixteen indigenous nut species

Breadfruit (*Artocarpus altilis*)

Breadfruit has a number of economic products, with the flesh of the fruit and the nuts eaten. Other uses include medicine, timber, fuelwood, canoe construction, clothing, rope, wrapping and adhesive (Ragone 2005). Both the flesh and nuts are eaten on the smaller islands off the north coast of New Guinea, on the Admiralty Islands, the Bismarck Archipelago, the Solomon chain, and throughout Milne Bay Province. In contrast, only the nuts are eaten on the mainland of New Guinea, with some exceptions, such as the mainland of Milne Bay Province and some coastal locations on the south of Central Province. As well, types of breadfruit with few or no seeds have been introduced into PNG from Polynesia over the past century, but these types remain uncommon. The fruit is cooked, commonly in a stone oven, but there are numerous ways of cooking and preparing breadfruit (Walter and Sam 2002:109). On Nissan Island, villagers preserve the flesh by roasting it to form a biscuit and this is said to remain unspoilt for several years (Bourke and Betitis 2003:65).

Breadfruit was domesticated by people in New Guinea (Yen 1996:37), probably thousands of years ago. From New Guinea, people spread the species in pre-European times throughout the Pacific islands, as far east as the Society Islands, north to the Marianas and north-east to Hawaii (Walter and Sam 2004:109). It was introduced into the Philippines in ancient times from Guam. Breadfruit has been introduced throughout the tropical world in recent centuries.

In PNG, breadfruit grows from sea level up to a mean of 1250 m, occasionally as high as 1450 m (Table 5), and is widespread throughout the Momase, Islands and Southern regions. It is also grown at lower altitudes in the highland provinces, up to about 1200 m. On the islands of New Britain, it was ranked by villagers as their most important fruit and nut bearing tree (Table 2).

Breadfruit does not produce fruit in a regular manner in most of PNG and the production period varies from year to year, despite many statements about its 'seasonality'. The exception is in Milne Bay Province at 8–11° south where villagers give the producing period as commencing in October or November. Production is likely to be seasonal at locations south of about 8° latitude, but is irregular at most locations in PNG, which are nearer the equator. Such a pattern would arise from the changes in day length during the year with increasing distance from the equator (Bourke et al. 2004:36–37).[3]

An estimated 2.4 million rural people grow breadfruit, which represents 57% of the rural population (Table 3). Breadfruit nuts are widely eaten throughout the lowlands, especially in Momase Region. The flesh is eaten on most islands in PNG and in a limited number of locations on the New Guinea mainland. Nuts are commonly sold in markets in Momase

[3] In our publication on production patterns (Bourke et al. 2004), we treat breadfruit as two species (*A. altilis* and *A. camansi*, the former termed 'breadfruit' and the latter termed 'breadnut'). In fact, the information on distribution and production patterns presented there is for breadfruit only (*A. altilis*).

Region. It is possibly now a less important food item than before the widespread adoption of sweet potato, cassava and *Xanthosoma* taro in the lowlands. It is not clear whether there is potential for further commercial sale of fruit and nuts within PNG. Fresh breadfruit is exported from Fiji to New Zealand and volumes grew rapidly over the period 2001–2005 (NWC 2005). There is little prospect of exporting breadfruit from PNG because of fruit fly infestation, but there may be a market for some fresh fruit in Port Moresby at least.

Candle nut (*Aleurites moluccana*)

This species has been described as '… one of the great domesticated multipurpose trees of the worlds' (Elevitch and Manner 2005:2). The seed can be eaten after being roasted. Consumption of raw seeds results in nausea and vomiting (as I found out in an early venture into gastronomy exploration on New Ireland in the early 1970s!). Candle nut is native to the Indo-Malaysia region and was introduced in ancient times throughout the Pacific islands (Elevitch and Manner 2005). Its pre-European distribution was from India in the west to the Marquesas Islands in the east; and from Australia in the south to Guam and China in the north, including New Guinea and associated islands (Walter and Sam 2002:88). It has now been introduced to much of the tropical world.

It is widely distributed throughout PNG, where it grows from sea level up to a mean of 1800 m and occasionally as high as 2160 m (Table 5). The limited information on the production pattern from Simbu Province, the Goroka area, New Ireland and New Britain indicate that fruit ripens seasonally between August and December (Bourke et al. 2004:37).

While the tree is widespread in PNG, the nuts are rarely eaten. It is most commonly used as a food in Simbu Province, where it is a very minor food item. It is occasionally eaten elsewhere, for example, in the Goroka area of Eastern Highlands Province and in the Morehead area of Western Province. The MASP database indicates that it is eaten by only about 8000 people. Nuts are occasionally sold in food markets in Simbu Province and in Goroka market.

Candle nut provides many economic products, including oil. This has a number of uses including for the cosmetics industry where it is used in products to sooth skin maladies (Elevitch and Manner 2005:13). It is also used as folk medicine, for animal fodder and as a dye. It is unlikely to be adopted as a food in PNG, but candle nut oil may have commercial potential for export.

Castanopsis (*Castanopsis acuminatissima*)

Castanopsis kernels are eaten either raw or cooked and are gathered from self-sown or planted trees. Henty (1982:80) reports that, in the Pomio area of inland New Britain, seeds were commonly eaten after boiling and that some children, against the advice of their elders, persistently ate raw kernels. Millar and Dodd (1982:201) compare the flavour to a walnut. The global distribution includes parts of India, China, Burma, Taiwan, Thailand, Vietnam, Laos, Indonesia and New Guinea (Walter and Sam 2002:137). Within PNG, the species is widespread on the New Guinea mainland, especially in the highlands and nearby locations, including in the Wau area of Morobe Province. It grows in the interior of New Britain and on some of the islands of Milne Bay Province. Castanopsis grows from a mean of 700–2350 m, and occasionally over the range 570–2440 m (Table 5).

The nuts are available seasonally, with a producing period of about two months that commences at some time between July and December. The limited available data suggest that the producing season commences earlier (July–September) at lower altitudes (800–1200 m) than at higher altitudes (1600–2000 m), where it commences in November–December (Bourke et al. 2004:38).

Castanopsis is eaten in parts of the highlands, the highland fringe and in the interior of New Britain. The MASP database indicates that about 293,000 people live in locations where the crop is commonly eaten (7% of the rural population) (Table 3). Most of those people (75%) live in Southern Highlands Province. Generally it is a minor food in PNG and is not seen as having much commercial potential.

Dausia (*Terminalia megalocarpa*)

Dausia is a minor species where the nut is eaten only after elaborate processing, which usually involves the fruit being soaked in water for some days. French (1986:172) reports that the outer flesh of the fruit is eaten and that a selected yellow-fleshed form is eaten in the Solomon Islands. The species is moderately common in the islands of Milne Bay, including Misima, Rossel, Sudest, Engineer Group, Calvados Islands, Trobriand Group, Iwa and other nearby islands. *Dausia* is a lowland species, and its upper altitudinal limit is not known. Nuts are available seasonally in the period December to February (Bourke et al. 2004:38). The MASP database indicates that 88,000 people live in locations where the species is commonly eaten. This is 2% of the rural population and all are located in Milne Bay Province. As far as I know, it is not sold in food markets.

Finschia (*Finschia chloroxantha*)

Finschia is a minor species. Nuts are gathered from self-sown trees and eaten raw. Henty (1982:81) notes that trees are sometimes planted near villages. The species is related to macadamia. Finschia is distributed through New Guinea, Solomon Islands, Aru Islands, Vanuatu and Palau Island (Micronesia) (Henty 1982). Within PNG, it has been recorded in Morobe, Eastern Highlands, Southern Highlands, Western, Gulf and Milne Bay provinces. It no doubt occurs elsewhere in PNG. Finschia grows from sea level up to a mean of 1850 m, and occasionally as high as 2000 m in PNG (Table 5). Production is reported to be seasonal, but there is insufficient data to generalise about the pattern. While the species is widely distributed in PNG, it is a very minor food, the nuts of which are eaten by some people occasionally. I have never seen nuts sold in food markets. It is not clear whether this species has any potential for further domestication or commercialisation.

Galip (*Canarium indicum*)

There are a number of domesticated *Canarium* species with edible nuts in PNG, including *Canarium indicum*, *C. decumanum*, *C. lamii* and *C. salomonense* (Kennedy and Clarke 2004; Yen 1996). There are other wild species, which are also eaten. *Canarium indicum* is the most widespread and important of the PNG species, and most of the rest of this section refers to that species. Yen (1996:41) states that *C. indicum* is the oldest domestic species in Melanesia, and plant remains appear in the archaeological record as early as 14,000 years ago, several thousand years before the start of arable agriculture in New Guinea. Thus the species was used in the late Pleistocene in the transition from a hunting-gathering economy to a horticultural-based economy. Yen (1996:41) also notes that the distribution of this species in the archaeological record implies the transportation at an early date of forms of the species that were already highly selected.

The kernel of *galip* is generally eaten raw, and sometimes roasted. Trees are grown from protected self-sown seedlings or planted seedlings. The species is present from northern Sulawesi in East Indonesia through New Guinea, the Solomon Islands and Vanuatu (Walter and Sam 2002:133; Kennedy and Clarke 2004:16). Yen (1996:38) presents a distribution map of seven edible *Canarium* species, including *C. indicum*. Within PNG, *galip* is widely grown below 500 m altitude along the north coast and inland areas of the New Guinea mainland and in the Islands Region (Figure 3). *Galip* grows from sea level up to a mean of 700 m, and occasionally as high as 930 m in PNG (Table 5). It is uncommon above 500 m altitude in PNG.

Nuts are produced seasonally with the producing period typically about three months long. Latitude has a strong influence on the start of the harvesting season, with the harvest commencing progressively later at locations further from the equator. At locations near the equator at 3–4° south, the producing season appears to be less well defined. There is no relationship between harvesting season and rainfall seasonality (Bourke et al. 2004:39).

About 1.347 million people live in locations where *galip* is commonly eaten in PNG (32% of the rural population) (Table 3). It is most common in Madang, East Sepik, East New Britain, Bougainville, Sandaun, Morobe, West New Britain, New Ireland, Oro and Manus provinces. Villagers on New Britain have ranked *galip* as one of the most important fruit and nut species on the island (Table 2). *Galip* nuts are widely eaten during the producing season. There are indications that consumption is somewhat less than in past generations. For example, puddings were made from *galip* and taro in some locations such as Bougainville, and this is rarely done now. Nuts are traded in some locations, for example, from Boisa Island to villages near the mouth of the Ramu River in Madang Province; on Vokeo (Wogeo) Island north-east of Wewak; and Siassi Islands in Morobe Province (Kennedy and Clarke 2004:17). Again there are indications that this trade has diminished in recent decades.

There is considerable potential for commercialisation of *galip* nut. Yen (1996:37) considered that 'Of all the food-producing trees in Melanesia, *Canarium's* almond-like nut probably has the greatest potential for commercialisation'. Thomson and Evans (2005a:2) similarly state that 'The species has a great, as yet largely untapped, economic potential for commercial development and export, mainly because of its abundance and non-perishable nut-in-shell'. They further note that the size of the international market for *Canarium* nut is very large. There has been one unsuccessful attempt to commercialise *galip* in PNG. This was in the Kandrian area on the south coast of New Britain (Evans 1994; Wissink 1996). This was done as part of the AusAID-funded Kandrian Gloucester Rural Development Project and the operation failed as soon as donor support ceased. This is a particularly difficult location in which to base a commercial *galip* industry, as the producing season (about May to August) coincides with the wettest period of the year where rainfall is often about 1000 mm per month. Sea transport links from the Kandrian area are also poor.

Evans (1996a) has estimated that there are about one million edible *Canarium* trees in PNG, with kernel production of 7200 tonnes per year. The yield from a plot of mature 10–15-year-old trees is estimated as 4–7 tonnes of kernel per hectare per year at a planting density of 100–250 trees per hectare (Thomson and Evans 2005a:11). One of the most important limiting factors for commercialisation is the high oil content of the kernel, as it becomes rancid unless processed adequately. The shell is very hard and considerable effort is required to break it to extract the kernel. Traditionally, this was done using stone tools, and is still the main technique used in PNG. However, this is not suitable for commercial use. Evans (1996b:69) lists research and development requirements to facilitate commercial production of *Canarium* nut.

***Karuka* (*Pandanus julianettii*)**

There are a number of *Pandanus* species that produce edible nuts in PNG, all of which grow above 1000 m. *Pandanus julianettii* and *P. brosimos* are the most important. Stone (1982:412) suggests that *P. julianettii* is the cultivated form of *P. brosimos*. The former is planted by people, while the latter is spread by animals. *P. julianettii* grows at a lower altitudinal range than *P. brosimos*, although the ranges overlap (Table 5). Kennedy and Clarke (2004) review the *Pandanus* species used as edible food in the south-west Pacific.

Nuts of *karuka* pandanus are an important dietary item during the producing season for those living at high altitudes in the highlands of New Guinea. The kernel is eaten raw or cooked by roasting in an open fire, baking in hot ashes or steaming in a stone oven (Rose 1982:162). Sometimes the complete cephalium (head-like ball) is immersed in mud or water for temporary storage. The nuts (kernels) can be preserved by drying and smoking on a bark platform above the household fire. For longer storage, the kernels are extracted and stored in baskets hung in the rafters of houses (Rose 1982). Smoke from the house fires imparts a characteristic flavour to the nuts.

Pandanus julianettii is endemic to New Guinea and is not grown elsewhere (Henty 1982:79; Stone 1982). Within PNG, it is confined to a narrow altitudinal band in the central and fringe highlands and on the Huon Peninsula (Figure 4). *Karuka* grows from a mean of 1800 m up to 2600 m, and occasionally as low as 1450 m and as high as 2800 m (Table 5).

Production is irregular in the western part of the highlands, where rainfall seasonality is slight or absent. In the eastern part of the highlands, where rainfall is seasonally distributed, production approximates an annual seasonal pattern, but there is still large year-to-year variation in the harvest size. In any year, the producing period also varies between locations. The nuts are most likely to mature during January–March, but nuts may mature during any month of the year. After periods of soil moisture stress or drought, the producing periods coincide at all or most locations. The biggest harvests tend to follow major droughts, such as those in 1965, 1972 and 1982, although there were no reports of especially large harvests after the major drought in 1997. Water stress is the likely cause of flowering rather than frost (Bourke 1996:49; Bourke et al. 2004:40).

Karuka is one of the most widely grown edible nuts in PNG, with almost half the national population living in locations where it is grown. The MASP database indicates that 1.975 million people live in locations where the crop is commonly eaten (47% of the rural population) (Table 3). It can be found in all mainland provinces, except East Sepik. Most (95%) of the people who grow *karuka* live in the five Highlands Region provinces and in Morobe Province. The nuts are an important food source during and after the producing period. When the nuts are in season, entire households, and their domestic pigs, commonly migrate from villages to high-altitude bush camps for some weeks to harvest and eat the nuts. *Karuka* nuts are commonly sold in highland markets. When sweet potato is scarce because of frost damage or other causes, villagers commonly survive on *karuka*. The nuts are highly nutritious and provide both protein and oil, the two components that tend to be deficient in highlanders' diets. Rose (1982:166) recorded crude protein of 13–15% (dry weight basis).

A survey in two highlands villages in 1984 recorded 176 and 12 *karuka* nut pandanus trees per household respectively (Table 7). In the same year, Bruce Carrad (pers. comm. 1988) conducted a census of *karuka* nut pandanus trees in Kamus village, Asaro Valley, Eastern Highlands Province, at 1900–2000 m altitude. The mean number of *karuka* trees there (765 trees per household or 225 per person) was much higher than the numbers recorded at Asiranka village (1600–1800 m) or Upa village (1700–2000 m). This is not unexpected, as Asiranka and Upa villages are at the lower limit of *karuka's* altitudinal range. In Kamus village, 42% of the trees were mature, somewhat more than in Asiranka village (28%), a reflection of the high planting rate in the years prior to the surveys. Hyndman (1984:295) recorded that each Wopkaimin man, who live in the mountains of north-west Western Province, maintains approximately 10 *karuka* trees and 10 *marita* trees.

Villagers commonly distinguish a number of cultivars of *karuka*. For example, people living near the Wage River west of Nipa in Southern Highlands Province distinguish at least 45 cultivars (Sillitoe 1983:105). In one area of the north Tari Basin, also in Southern Highlands Province, Rose (1982) recorded data on 17 named cultivars.

Karuka nut is highly sought after by highlanders and is popular with non-highlanders who live in the region. It has potential as a cash crop within PNG and perhaps as an exotic export crop.

Wild *karuka* (*Pandanus antaresensis*)

Nuts of a number of wild pandanus species are eaten occasionally, including *P. antaresensis*. This species is endemic to New Guinea (Stone 1982). Within PNG, it grows in an altitudinal band of 1000–2350 m on mainland provinces. It occasionally grows as low as 850 m (Pindiu, Huon Peninsula) and as high as 2460 m (Gumine, Simbu Province) (Table 5). I have recorded wild *karuka* in the Highlands Region and in Western, Madang and Morobe provinces, but it probably grows in all provinces on the New Guinea mainland. The only information on the production pattern is a comment by Hyndman (1984:296) that it bears continuously throughout the year.

Some people in the highlands and highland fringe eat the nut of this species, but in many locations it is not known as a food. Even where it is eaten, it is a minor food and is only used by a limited number of people. The shell is thick and hence it is difficult to extract the kernel. Hyndman (1984:297) notes that prominent aerial stilt roots with large spines make this species too difficult to climb and, in the Wopkaimin area, the fallen ripe cephalia are collected from the ground. Nuts are not sold in food markets. It probably has no potential for commercial development as a food crop.

Wild *karuka* (*Pandanus brosimos*)

This species is similar to the cultivated *karuka* nut (*Pandanus julianettii*) and the expert on the botany of the genus, Ben Stone (1982:412), believes that the cultivated form is a cultivar of *P. brosimos*. As with cultivated *karuka*, *P. brosimos* is an important food for those living at high altitudes in New Guinea, although it is not quite as important as *P. julianettii*. Wild *karuka* is endemic to New Guinea and is not found elsewhere (Stone 1982). Within PNG, it is widespread in a high altitudinal band (2400–3100 m) in the central and fringe highlands and on the Huon Peninsula. It occasionally grows as low as 1800 m and as high as 3300 m (Table 5). Thus it is found at the top of the range of food gardening in PNG (up to 2850 m) and some hundred of metres higher.

Production is discontinuous and non-seasonal. Nuts are most likely to mature in January–February, but may mature in any month. The producing period may coincide with that of *P. julianettii* at lower altitudes in the same region, but this does not always occur (Bourke et al. 2004:41).

The MASP database indicates that 1.322 million people live in locations where the crop is commonly eaten (32% of the rural population) (Table 3). It can be found in all mainland provinces, except East Sepik. Most (91%) of the people who grow wild *karuka* live in the five provinces of the Highlands Region and in Morobe Province. Nuts have not been noted in highland markets, but it is possible that they are sold in high-altitude locations.

P. julianettii is likely to have greater potential for commercialisation than *P. brosimos* because the shell of the cultivated *karuka* is usually easier to break. Nevertheless, the wild species may be an important source of breeding material if improved types are to be bred in the future.

Okari (*Terminalia impediens*)

The name *okari* is used in Motu (and now English) in the Southern Region for *Terminalia kaernbachii*, but it has been adopted in Tok Pisin as the term for the related *T. impediens*.

The kernel of *T. impediens* is eaten raw. Trees are not planted, but are preserved when land is cleared for gardening. It is endemic to New Guinea (Henty 1982:83). Within PNG, it is most common in East Sepik, Madang, Sandaun and Morobe provinces. Henty notes that a few botanical collections have been made in Central and Gulf provinces. I have also seen it on the Managalas Plateau in Oro Province. *T. impediens* grows from sea level up to a mean of 1000 m, and occasionally as high as 1100 m (Table 5). There is no clear indication of the production pattern.

The MASP database indicates that about 340,000 people live in locations where the crop is commonly eaten (8% of the rural population) (Table 3), but this probably overestimates the importance of the species as it is a very minor food item in the locations where it grows. Most of those people live in East Sepik, Madang and Sandaun provinces. I have not noted it in fresh food markets, but it may be sold sometimes. This species has much less potential than the closely related *T. kaernbachii*, although it could possibly be developed as a commercial crop.

Okari (*Terminalia kaernbachii*)

Okari nuts are eaten raw. The nuts are greatly appreciated by Papua New Guineans and non-Papua New Guineans alike. Evans (1996a:22) notes that 'Many would consider *okari* nut to be the best tasting indigenous nut in the Pacific'. Trees are preserved in garden land or planted. Villagers either harvest nuts from trees or, more commonly, collect the fallen fruit. The species is endemic to New Guinea and is also found on the Aru Islands (south-west of New Guinea). *Okari* has been introduced to the Solomon Islands, Australia and Sri Lanka (Evans 1996a:22; Henty 1982:83; Walter and Sam 2002:260). Within PNG, *okari* is mainly distributed in the Southern Region in Central, Oro, Gulf, Western, and Milne Bay provinces. It also occurs in adjacent locations in Southern Highlands and Simbu provinces, in the Mumeng-Wau-Menyamya area of Morobe Province, and in West New Britain from the Aria River west to Cape Gloucester (Bourke 1996:50). Over the past 50 years, the tree has been taken from its area of natural distribution to other locations in PNG, including East New Britain, New Ireland and as far east as Makira in Solomon Islands.

Okari grows from sea level up to a mean of 1100 m, and occasionally as high as 1260 m (Table 5). The species is uncommon near the ocean in its natural range in southern New Guinea, although it does seem to produce well near the ocean, for example at Keravat on New Britain or at Kavieng on New Ireland. It may be that the best production occurs where the diurnal temperature range is greater (day to night variation), or perhaps people did not plant it near the sea where coconuts and sea almond were available. Fruit produces seasonally (Bourke et al. 2004:41–42). Experimental recordings at Keravat suggest that the start of the producing period is fairly constant from year to year, although the size of the harvest varies each year. The harvesting period is two to four months long. There is a clear relationship between latitude and the start of the harvesting period, with the producing period commencing later at locations further south from the equator (Bourke et al. 2002:42, 156). This is presumably caused by differences in day length, although it could also be related to seasonal temperature changes.

About 528,000 people live in locations where *okari* is commonly eaten in PNG (13% of the rural population) (Table 3). Most of those people (80%) live in the Southern Region, and the rest in adjacent locations on the southern fringe of the central highlands and in Morobe, Manus and West New Britain provinces. During the producing season, *okari* nuts are commonly eaten in the producing region and some are sold in local and regional markets, including in Port Moresby.

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Okari nut has considerable potential for sales within PNG and overseas. It is a high quality nut and is highly regarded by those who have tasted it. There is much that is poorly understood about the agronomy, processing and marketing of the nut. On the Managalas Plateau in Oro Province, a 1985 census recorded 6300 mature *okari* trees in a 5000 ha area. Yields were recorded as 480 nuts per tree, with an estimated average yield of 4.8 kg of kernel per tree (Anon. 1985). Using these figures it was estimated that 30 tonnes of kernel was potentially available from this area each year. Average consumption was recorded as 25 kg per person in 1985, or 2.5% of the potential harvest (Anon. 1985). Production of about 5 kg of kernel per tree is in the range of 0.5–10 kg kernel per tree per year estimated by Evans (1996a) who provided an overview of some characteristics of the species. In another paper, Evans (1996b:72) summarises some of the research and development issues that need to be addressed for the species to be commercialised.

A local NGO called Okari Ecoenterprises attempted to commercialise *okari* nut on the Managalas Plateau in Oro Province in the early to mid 1990s (Ase 1996; Houghton 1996; Olsson 1996). Nuts were collected from planted and self-sown trees and transported to Port Moresby where they were sold through Associated Distributors (Andersons). The operation folded a few years after it started, possibly because of an insufficient and irregular supply of nuts, rather than constraints at the retail level in Port Moresby, where the processed nuts were in high demand.

Pao (*Barringtonia procera*)

There are three main species of *Barringtonia* with edible nuts in the western Pacific: *Barringtonia procera*, *B. edulis* and *B. novae-hiberniae* (Jebb 1992:165; Evans 1996a; Walter and Sam 2002; Pauku 2005a). The last-named is found mainly in the wild form in forests, is largely undomesticated and is less abundant around villages. The distinction between *B. procera* and *B. edulis* is not easy because of the great variation within each of the two species, which means that morphological characteristics can overlap (Pauku 2005a). *B. procera* is the most important of the species in PNG. However, *B. edulis* is important in some locations. For example, Millar and Dodd (1982:201) note that the Russian botanist Miklouho-Maclay recorded *B. edulis* as being a very common tree in villages on the Rai Coast in Madang Province in the 1880s. The kernel is eaten either raw or roasted. *B. procera* is always planted.

The three species of edible *Barringtonia* are distributed from New Guinea through the islands as far east as Fiji (Evans 1996a:20; Walter and Sam 2002). Distribution of *B. procera* was restricted to parts of the Islands Region of PNG, the Solomon Islands and north and central Vanuatu. Within PNG, it was limited to Bougainville, Buka, New Ireland and Manus islands and the Gazelle Peninsula of New Britain (Bourke 1996:48). Since about 1960, the species has been planted at other locations on New Britain and the New Guinea mainland, including coastal and island locations in Morobe, Madang, East Sepik, Sandaun and Milne Bay provinces.

Jebb (1992:177) suggests that *B. procera* originated in the Solomon Islands as collections have been made in the forest only in the Solomon Islands. This suggestion is consistent with the limited distribution in PNG. I suggest that the species was brought by people from the northern Solomon chain (Bougainville and Buka) to New Ireland and the Admiralty group. Later it was taken by migrants from southern New Ireland to the Gazelle Peninsula of New Britain. Thus the species may have been present in what is now PNG for a relatively short time, perhaps less than 1000 years.

B. procera is very much a lowland crop and grows from sea level up to a mean of 500 m, and occasionally as high as 620 m in PNG (Table 5). *Pao* fruits intermittently in a non-seasonal manner in PNG (Bourke et al. 2004:42). The MASP database indicates that about 561,000 people live in locations where the crop is commonly eaten (13% of the rural population) (Table 3). It is most common in East New Britain, Bougainville, New Ireland, West New Britain and Manus provinces. This species is still a minor food on the New Guinea mainland, although it is increasing in importance. *Pao* nut is an important food in the Islands Region and is commonly sold in food markets.

Edible *Barringtonia* species have been commercialised in Vanuatu where there is high demand for the nuts (Long Wah 1996). *B. procera* in particular has considerable potential as a cash crop for both the domestic and export markets, given the small area required per tree, a relatively short time to maturity and the possibility of growing it as a horticultural crop rather than relying on naturally occurring forest trees. As with other South Pacific indigenous nuts, processing issues need to be improved to facilitate commercialisation (Evans 1996b). However, there are probably fewer issues that need to be addressed than for *okari* or *galip*, given that the kernel is not oily and the 'nutty' flavour of *pao* is readily accepted by Western consumers.

Polynesian chestnut (*aila*) (*Inocarpus fagifer*)

The seed of Polynesian chestnut is cooked prior to consumption. It is cooked by baking the entire fruit or boiling or roasting the nut. Polynesian chestnut is found near villages, rivers and in or near food gardens at low altitudes. It is distributed from Java and Borneo in the west through New Guinea and the island chains as far south as New Caledonia and as far east as east Polynesia (Walter and Sam 2002:184). Within PNG, it is grown in the lowlands of the mainland and island provinces. It is not common on the New Guinea mainland, except in Milne Bay Province, where it is important on both the mainland and on all larger islands. Polynesian chestnut is also commonly grown on New Britain and New Ireland. Polynesian chestnut grows from sea level up to a mean of 400 m, and occasionally as high as 870 m in PNG (Table 5).

Production in PNG is discontinuous and non-seasonal at locations closer to the equator. In Milne Bay Province (8–12° south), fruit ripens seasonally over a two to three month period, especially in November–February (Bourke et al. 2004:43).

The MASP database indicates that 637,000 people live in locations where the crop is commonly eaten (15% of the rural population) (Table 3). Most (83%) of those people live in Milne Bay, East New Britain, West New Britain and New Ireland provinces, with the rest in the other lowland provinces. In most locations, Polynesian chestnut is only a moderately important food. It is most important in Milne Bay Province, where it is available on a predictable seasonable basis during the period when garden food is scarce. However, since the widespread adoption of sweet potato and cassava, it seems to have become a less important food there, as the tuber vegetables are available throughout the year. The decline in the importance of the nut as a food is a Pacific-wide phenomenon (Pauku 2005b:3–4). Cooked nuts are sold occasionally in markets in the islands in PNG.

Polynesian chestnut is not a popular food with those who did not grow up eating it. For that reason, it is unlikely to have great potential for commercial production within PNG or overseas. Evans (1996b:72) notes that standard techniques for the removal of the toxins need to be developed for commercial production.

Sea almond (*talis*) (*Terminalia catappa*)

The small kernel of sea almond (*talis* in Tok Pisin) is eaten raw or roasted. Sea almond is widely distributed in PNG along the seashore. It is sometimes planted in coastal villages and inland villages. It has also been planted as a street tree in a number of PNG towns (Henty 1982:82). Sea almond has a widespread natural distribution in near-coastal areas of the Indian Ocean, through tropical Asia and into the Pacific Ocean (Thomson and Evans 2005b:2). Its range extends from India and Sri Lanka in the west to the Marianas Islands in the north to eastern Polynesia and northern Australia (Walter and Sam 2002:256).

Within PNG, the species can be found on the coast of all lowland provinces (Bourke 1996:50). It is most common in Milne Bay Province and the Islands Region provinces. Sea almond grows from sea level up to a mean of 300 m, and occasionally as high as 460 m in PNG (Table 5). It fruits sporadically throughout the year nearer the equator, but has heavier crops toward the end of the year at locations further from the equator (Evans 1996a:22). The available and limited information on its production pattern in PNG indicates that production is seasonal, with fruit ripening sometime between November and May. In Milne Bay Province, where sea almond is a more common food, the producing period is reported by villagers as 2–3 months long, with December–February as the most commonly reported time of fruiting (Bourke et al. 2004:44).

The MASP database indicates that about 568,000 people live in locations where the crop is commonly eaten (14% of the rural population) (Table 3). This overestimates the importance of the species as it is a very minor food item in most locations where it grows and it is mostly only eaten by people who live near the seashore. It is most widely used as a food in Milne Bay Province, and also in East New Britain, New Ireland and West New Britain provinces. My observation in Milne Bay and the Islands Region is that sea almond is not a commonly eaten food, and then the kernels are mostly eaten by children. Lepofsky (1992) notes that, on

Mussau Island north of New Ireland, there were once strict laws concerning who was able to harvest trees, but today the nuts are eaten mostly by children. Sea almond is, however, more important on some islands. For example, on Iwa Island in the Marshall Bennett Group in Milne Bay Province, soft-shelled nuts occur. They are preserved by smoking and exported to nearby islands such as Woodlark (Bourke 1996:53). On Mussau Island, there is also reported to be a variety with a soft external skin which can be easily broken with the teeth (Lepofsky 1992:195).

I have not seen kernels sold in PNG markets, such as occurs in the fresh food market in Port Vila in Vanuatu, but they may be sold sometimes. The species has potential for commercialisation for sale within PNG and overseas as it is a tasty nut. Processed sea almond kernels are sold in stores in Port Vila (Long Wah 1996). Evans (1996a) and Thomson and Evans (2005b) summarise information on estimated tree yields and other characteristics, while Evans (1996b:72) notes some issues that need to be addressed to facilitate commercial exploitation. One of the most important limiting factors is the small size of the kernel, and it would be desirable for any commercial production to be based on cultivars with larger kernels.

Sis or *solomon* (*Pangium edule*)

The seed of *Pangium edule* is widely eaten in PNG, despite it requiring extensive processing to remove a toxic substance, a cyanogenic glycoside (French 1986:193; Henty 1982:80–81). The seed is only eaten after being washed in water, then roasted and fermented. *P. edule* is known by the common name *sis* in some locations in Momase Region and s*olomon* in parts of New Britain. It is distributed from Malaysia in the west to Vanuatu in the east (Walter and Sam 2002:220). Within PNG, it is grown in all provinces and the seed is eaten in most provinces. *Sis* grows from sea level up to a mean of 1050 m, and occasionally as high as 1380 m in PNG (Table 5). Production is seasonal, commonly starting around May or June and lasting 2–4 months (Bourke et al. 2004:44).

The MASP database indicates that about 336,000 people live in locations where the crop is commonly eaten (8% of the rural population) (Table 3). It is reported as being eaten in most provinces, and is most common in Milne Bay, West New Britain, Madang, Southern Highlands, Sandaun and Morobe provinces. It was ranked by villagers on New Britain as a moderately important nut species (Table 2). Nuts being are occasionally sold in food markets.

Because of the extensive processing required to make the nuts safe for human consumption, it is unlikely that this species has any commercial potential. However, there may be non-food uses for products from the tree.

Tulip (*Gnetum gnemon*)

Tulip is an important food crop in many locations in New Guinea, especially in East Sepik and Sandaun provinces, where the young leaves are an important green vegetable. The young flowers, young fruit and ripe fruit are also eaten (French 1986:57). The ripe fruit containing the seeds (‘nuts’) is eaten cooked, either boiled or roasted. The species is distributed from Assam (India) through Indo-China, Malaysia, Indonesia, New Guinea, Solomon Islands, Vanuatu and Fiji (Walter and Sam 2002:181). Within PNG, it is very widely grown on the island of New Guinea. It is present in the Islands Region, but is a less common crop. Trees are planted and self-sown. *Tulip* grows from sea level up to a mean of 1100 m, and occasionally as high as 1330 m (Table 5). The limited information on fruit availability indicates that it ripens in December–February (Bourke et al. 2004:14).

The MASP database indicates that *tulip* fruit and ripe seed are eaten by about 68,000 people, or less than 2% of the rural population (Table 3). However, this figure underestimates the number of people who eat the fruit and ripe seed occasionally. The fruit is sometimes eaten in lowland locations in all mainland provinces. Overall, *tulip* seed is a minor food, with the main food product from the *tulip* tree being the young leaves. It is not clear whether this species has any potential for further domestication or commercialisation.

Discussion

Five of the species discussed here are considered as having significant potential for commercial development. These are *galip*, *karuka*, *okari*, *pao* and sea almond (Bourke 1996). Nuts of three of these are sold as processed nuts in modern packaging in Vanuatu, although the actual Vanuatu species differ from the PNG ones. These are *Canarium* species (*nangai* in Bislama), *Barringtonia* species (*navele*) and sea almond (*natapoa*) (Long Wah 1996). The operation in Port Vila has been sustained for the past 15 years. In the Solomon Islands, processed *Canarium* nuts were being sold in retail outlets in Honiara in 2005.

There have been two unsuccessful attempts to commercialise two of PNG's indigenous nuts: *galip* in the Kandrian area on the south coast of New Britain and *okari* on the Managalas Plateau in Oro Province. These failed projects in PNG in the early to mid 1990s indicate that establishing a viable domestic or export industry for processed indigenous nuts is not easy. Nevertheless, the successes in nearby Vanuatu and Solomon Islands show that it is possible, provided that the operation is run by the private sector or a local non-government organisation and not by a donor-funded project or government.

A number of factors are limiting the commercial development of edible indigenous nuts in PNG. These include the lack of suitable mechanical crackers to extract the kernel from the shell, especially for *galip* which has a particularly hard shell. Currently, this is done by hand using stone tools, but this is laborious and potentially risky for the fingers of the operator. For some species, mature trees are very large, including *galip*, *okari* and Polynesian chestnut. Smaller trees would be easier to manage and harvest.

Basic information is lacking for all species on yield potential, yield patterns over the life of trees, the productive life of plantings and variation within populations. Such data are basic for investing in plantations and commercialisation. Evans (1996b) gives a valuable summary of aspects of indigenous nuts that are poorly understood, but which need to be known to facilitate development. He notes that most research and development requirements are to do with either resource sustainability or quality assurance during processing.

There is significant commercial potential for at least five of the forty-plus indigenous edible nuts in PNG. In the medium to long term, the indigenous edible nuts could be worth many hundreds of millions of kina to the PNG economy, and worth more than the existing major export cash crops. Much remains to be learnt about the trees and the markets. The best way to deal with these unknowns is to begin the commercialisation process and to address the constraints as they are identified.

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