Edible Nut Trees in Solomon Islands: A Variety Collection of *Canarium*, *Terminalia* and *Barringtonia*

Barry R. Evans

1999

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PREFACE

THIS report originally appeared as 'A variety collection of edible nut tree crops in Solomon Islands' in December 1991 as an unpublished Research Bulletin (No. 8) of the Division of Research, Ministry of Agriculture & Lands (MAL, now Ministry of Agriculture & Fisheries [MAF]), Solomon Islands. The original report was written mostly in the UK (after the author had left Solomon Islands in May 1991) with the financial assistance of the UK Government's Overseas Development Administration (ODA, now known as the Department for International Development [DFID]) through its former British Development Division in the Pacific, Suva, Fiji).

The report was revised in 1994 and submitted to the South Pacific Commission (SPC) for publication, while the author was a visitor at the Department of Botany, University of Queensland (UQ), Australia, and supported by the Australian Centre for International Agricultural Research (ACIAR). Unfortunately, SPC did not publish the report as planned and it is only now that the opportunity has arisen to further edit and publish it as part of the ACIAR's technical report series.

Background information on the Solomon Island Edible Nut Tree Crops (ENTC) Project and credits for the original research and field work are given in the Introduction and Acknowledgments. The kind permission of MAF in Solomon Islands and DFID in UK to publish the report is gratefully acknowledged, as is the generous support of UQ and ACIAR.

I would also like to thank Doug Boland (Project Director of the South Pacific Regional Initiative on Forest Genetic Resources [SPRIG]) and Lex Thomson (SPRIG Project Team Leader) for encouraging and supporting the publication of this report.

Barry Evans
Brisbane
March 1999

TABLES

FIGURES and PLATES

ACRONYMS and ABBREVIATIONS

Abbrev.	Meaning	Notes
aff.	affinis (latin): related to	
BAREDU	*Barringtonia edulis*	cut nut
BARNOV	*Barringtonia novae-hiberniae*	cut nut
BARPRO	*Barringtonia procera*	cut nut
BSIP	Honiara Botanical Gardens	
CANHAR	*Canarium harveyi* var. *nova-hebridiense*	Santa Cruz nut
CANIND	*Canarium indicum* var. *indicum*	ngali nut
CANSAL	*Canarium salomonense* ssp. *salomonense*	adoa
CIP	Central Island Province	
dbh	diameter at breast height	
DCRS	Dodo Creek Research Station	
DFID	Department for International Development (formerly Overseas Development Administration (ODA))	U.K. Government
ENTC	Edible Nut Tree Crops	
FES	Field Experiemental Station	
GC	Guadalcanal Province	
ISA	Isabel Province	Santa Isabel
K/N	Kernel/Nut ratio	
KIT	Kernel(s)-in-testa	
m.c.	moisture content	
MAK	Makira Ulawa Province	San Cristobal
MAL	Malaita Province	
NIS	Nut(s)-in-shell	
NRI	Natural Resources Institute	ODA
PNG	Papua New Guinea	
SI	Solomon Islands	
spp.	species	
ssp.	sub-species	
syn.	synonym	
TEM	Temotu Province	Santa Cruz Islands
TERCAT	*Terminalia catappa*	alite nut
TERKAE	*Terminalia kaernbachii*	bush alite
Van.	Vanuatu	
var.	variety	
WP	Western Province	

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Noel Roposi (Research Officer) my assistant during the later part of the project; Ken Trewren (Department for International Development (DFID) [formerly Overseas Development Administration (ODA)] Corps of Specialists and Tree Crops Advisor) for help and advice throughout the project; John Abington (ODA Corps of Specialists and former Director of Research); Ruth Liloqula (Director of Research); Dr Ivan Ivanochic (UNDP volunteer and Taro breeder) for help with the floral biology of *Canarium harveyi*; and Rob Moss (ODA TCO and former SRO for Field Crops) for editing the completed text.

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The chief agricultural extension officers of the seven provinces and their staff for their help in organising tours and collecting specimens.

Much of the work is based on the substantial knowledge local people have of edible nut trees. Without such knowledge, it would have been impossible to carry out the work in the allotted time.

Elsewhere:

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The project was funded by the British Government Overseas Development Administration through the British Development Division in the Pacific, Suva, Fiji.

SUMMARY

THIS technical report summarises results of a variety collection of indigenous edible nut tree crops of the genera *Canarium*, *Terminalia* and *Barringtonia* in Solomon Islands.

More than 200 trees were inspected over a three-year period (1988–1991). Detailed records were taken of 97 trees, the majority being *Canarium* species.

Of the three edible *Canarium* species (ngali nuts) found in Solomon Islands, intra-specific variation in key nut-in-shell (NIS) characteristics was greatest within *C. indicum*. The size and weight of many of the Santa Cruz ngali nuts (*C. harveyi* var. *nova-hebridiense*) collected significantly exceeded that previously reported and is undoubtedly due to intense selection on a limited number of small islands.

C. harveyi var. *nova-hebridiense* was found to be polygamodioecious, not dioecious as are most other *Canarium* species (Leenhouts 1959).

An infra-specific classification of edible Solomon Islands *Canarium* is presented based on genotypic easy-to-measure NIS characteristics.

The collection of *Barringtonia edulis* confirms its existence in Solomon Islands and contradicts previous records (Payens 1967) of it being endemic to Fiji.

Nine cultivars of the three edible *Barringtonia* species are described.

Background information on the three genera and a review of literature is presented. A checklist of vernacular names is given as a reference document. A listing of all specimens collected is given in the Appendix, along with a detailed field description of *C. harveyi* var. *nova-hebridiense*.

FOREWORD

ANY observant visitors to Melanesian villages in the Pacific will notice several indigenous nut tree species of varying ages growing somewhat haphazardly around village homes and in bush gardens. The more curious visitors might be tempted to inquire about the names of these little known tree crops, what varieties are grown, what do the nuts taste like, and maybe seek nuts in local markets to buy and eat. Our curious visitors might even be tempted to think about the local domestication processes that resulted in these varieties being selected and grown. Indeed bigger questions might also arise like — where in the Pacific might one find the best concentration of varieties of any particular species? Finally, if our visitors were commercially orientated, they might wonder why local villagers have not developed these species agronomically as an export crop.

There is no doubt that edible nut trees have been cultivated in Melanesia for a long time and that movement of varieties amongst islands has occurred over centuries. Most informed observers will acknowledge that we lack precise information on the varieties already in use. We also lack easily applied scientific criteria to use as a base for comparing one variety against another. Furthermore, with the impact of western influences, local knowledge on varieties is slowly disappearing and valuable nut-bearing trees are being lost. Knowledgeable workers in the area believe that conservation of both local knowledge and tree resources is required now.

Barry Evans and his colleagues in the Solomon Islands have attempted to identify new varieties and to categorise and evaluate them. To achieve this, he led germplasm collection teams to villages seeking new varieties and devised a simple method to evaluate each variety. His approach to collecting was biased towards *targeted*, rather than *random*, collections whereby villagers identified outstanding individual trees for the collection team. This approach is somewhat similar to that used by cereal germplasm collectors in developing nations who sometimes examine farmers' grain storage bins for unusual varieties. In Barry's case, villagers sometimes had nuts for him to sample in their homes, or trees to take him to on their land. I believe Barry's approach to collection was the correct one and very cost effective, and furthermore, strongly believe that this resource must be documented more widely before we can move any further forward in the development of these crops.

What Barry has achieved in the Solomon Islands, as described in this report, needs to be undertaken in other neighbouring countries. Some of this work has been done but much, much more can be achieved in documenting and conserving the resource before it is lost. Assembling base genetic resource conservation collections on forestry/agricultural field stations, as was the approach adopted in the Solomon Islands, also has much merit. We all acknowledge difficulties ahead associated with farmers rights, intellectual property rights etc. but these issues can be resolved in time for the betterment of all. Barry's approach is a model for other collectors to follow.

Barry is one of a small band of dedicated specialists in the Pacific trying to bring the true potential of these edible nut tree crops to local and international attention. I first heard of

Barry's work in the Solomon Islands while developing a *targeted* collection program for the International Centre for Research in Agroforestry on another indigenous tree crop, bush mango (*Irvingia gabonensis*), in West Africa. The tales heard then, in far away Nigeria, increased my desire to learn more of Barry's methods and approaches to domesticating indigenous nut tree crops.

The relevance of my comments in this foreword is that I am currently involved in an AusAID funded regional project titled the South Pacific Regional Initiative on Forest Genetic Resources (SPRIG) which seeks to identify, document, evaluate, conserve and develop a wide range of tree species for forestry and agroforestry purposes in Fiji, Vanuatu, Samoa, Solomon Islands and Tonga. Barry's goals are not too dissimilar from those of SPRIG.

I would recommend Barry's approach to collection to other tree nut/tree fruit collectors as he has provided a model for others to follow. We all look forward in the years ahead when these nut tree crops change status from lesser- to better-known, when they become more systematically conserved, and, when they become better developed as commercial crops in which the villagers benefit from their ancestors foresight.

D.J. Boland
Project Director
South Pacific Regional Initiative on Forest Genetic Resources

1. INTRODUCTION

The Solomon Islands is a double chain of mainly volcanic islands (total 28 300 km^2) lying in the humid tropics of the southwest Pacific (5–12°S and 155–170°E). The islands form part of an area known as Melanesia which includes Papua New Guinea (PNG), Vanuatu and Fiji. In 1986, the population of Solomon Islands[1] was 285 000 (10 persons/km^2) with an annual growth rate of 3.5%. Nearly 90% of the population still live in rural (mainly coastal) villages, but urban migration, mostly to the capital Honiara, is increasing rapidly (Mackey 1989).

Like many of its neighbours, Solomon Islands' economy relies heavily on fishing, logging and a few agricultural cash crops for foreign exchange. Copra, cocoa and oil palm presently contribute almost 100% of agricultural export value, but the real price of these commodities has fallen over the past 20 years.

The pressure on fishing and logging has consequently increased, but there is a growing awareness (and unease) of the environmental and social costs involved in the further, often indiscriminate, development of both activities.

Most efforts to introduce other *exotic* agricultural cash crops (such as rice, spices and fruits) have not been as successful as hoped because of a lack of investment and training, low returns, pest and disease problems, and poor storage and transport.

There are, however, many *indigenous* agricultural crops in Solomon Islands, which possess export potential (Henderson and Hancock 1988). One example is the ngali nut which grows on large forest trees (*Canarium* spp.) common in Solomon Islands and in neighbouring Vanuatu and PNG. The trees do grow wild, but most have been planted near villages by local people who harvest the nuts each year and eat the kernels fresh or preserve them in-shell. The kernels have a pleasant, subtle flavour highly esteemed by locals and visitors to Solomon Islands. Furthermore, the nuts-in-shell are robust, non-perishable and resistant to vermin, making them suitable for the rudimentary storage and transport facilities available in Solomon Islands.

Consequently, ngali nuts have long been considered as a potential *cash* crop in Solomon Islands, but until recently no action has been taken to develop them.

International concern over the rapid depletion of rainforests has also focused attention on the need to develop indigenous non-timber forest products as sustainable alternatives to logging. However, there is often little scientific knowledge of these products and barely any experience on how to develop them. Apart from some botanical work, there is little recorded information on edible nut tree crops in Solomon Islands and only in the Philippines is there some experience of processing and marketing *Canarium* nuts commercially.

In 1988, a project was initiated by the Solomon Islands Ministry of Agriculture and Lands and the British Government's Overseas Development Administration to investigate the

[1] 'Solomon Islands' should be distinguished from 'The Solomon Islands'. The latter refers to a geographical area which includes Bougainville Island. The former is a country which, until independence in 1978, was known as the British Solomon Island Protectorate, and excludes Bougainville (which belongs to PNG).

potential of ngali nuts, and other indigenous edible nut tree crops, as smallholder-based cash crops in Solomon Islands.

The project was divided into three main parts:

1. Identification and collection of superior varieties of ngali nut (*Canarium* spp.), alite nut (*Terminalia* spp.) and cut nut (*Barringtonia* spp.).
2. Research on the agronomy of ngali nuts.
3. Development of techniques for production, processing and marketing of ngali nuts.

This document is the technical report on the results of the variety collection (part 1 above)[2].

The report is divided into three main sections: the first section presents background information on the taxonomy of the three genera, reviews related work, and briefly describes other indigenous nuts in Solomon Islands; after a brief description of the methods used in the variety collection, the second main section presents the results of the edible nut tree crop (ENTC) variety collection; and finally, the last section discusses the results and their implications for the rest of the project work, and proposes a classification system for edible *Canarium*.

Most of the report concerns *Canarium*, because this genus was identified at the beginning of the project as having the greatest economic potential for commercial development, mainly because of its abundance and non-perishable nut-in-shell.

The results in this report are seen as part of the necessary groundwork for a future tree breeding program, which is seen as an essential step towards achieving the long-term goal of developing ngali nuts (in particular) as a smallholder-based cash crop.

Although significant amounts of botanical information is included, this report is **not** a revision of the respective taxonomy of the three genera concerned; it merely appends to their existing monographs.

This report also aims to establish standards for the future collection, description, identification and classification of indigenous ENTC in Solomon Islands and neighbouring countries.

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[2] Separate reports have been issued for parts 2 and 3 of the project (Evans 1991a and 1991b respectively).

2. BACKGROUND INFORMATION

2.1 *Canarium*

2.1.1 Taxonomy

THE genus *Canarium* belongs to the family Burseraceae. Two other genera belonging to Burseraceae are found in Solomon Islands: the uncommon *Haplolobus* (two species recorded, but very possibly more), which includes *H. floribundus* (Schum.) Lamk. ssp. *salomonensis* (C.T. White) Leenh.—a staple nut ('gemugi') of the Rennel Islands (Henderson and Hancock 1988)—(see Section 2.5) and; *Garuga*, represented solely by *G. floribunda* Decne. which is found only in the drier areas of North Guadalcanal (Whitmore 1966).

The comparative taxonomy of *Canarium* is based on floral, fruit and stipule[1] morphology (Lam 1931, 1932; Leenhouts 1955, 1959). The c. 70 species in the genus are currently divided in to 3 subgenera, 4 sections and 11 groups (Leenhouts 1966, 1972a).

Eight species of *Canarium* have been *collected* in Solomon Islands, with a further three *possibly* present (Tables 1 and 2). Three species—*C. indicum*, *C. salomonense* and *C. harveyi*—are described as being common (Whitmore 1966). The former is easily distinguished, but the latter two are rather close in their vegetative characteristics.

C. indicum var. *indicum*, *C. salomonense* ssp. *salomonense* and *C. harveyi* var. *nova-hebridiense* have edible kernels (Henderson and Hancock 1988). Leenhouts (1955, 1959) records the mesocarp of *C. vitiense* from Fiji, Samoa and Tonga as being edible (as does Hewson (1985) in Australia), but there are no records of their being eaten in Solomon Islands. *C. vulgare* (kenari nut) has edible kernels which are popular in eastern Indonesia, but the species is slowly replaced by its close relative *C. indicum* east of the Moluccas Islands.

The demarcation between the uncommon, but closely related, *C. asperum*, *C. vitiense*, *C. vanikoroense* and *C. liguliferum* (plus the unconfirmed *C. acutifolium* and *C. chinare*), which all belong to the same taxonomic group, is very small and complicated, and has been subject to a number of revisions (Leenhouts 1955, 1956, 1959 and 1965).

The flowers of most *Canarium* species are recorded as dioecious.[2] This feature, combined with a geographically large (and often isolated) range and the human cultivation of many species, appears to have led to both large inter and intra species variation. It seems likely, therefore, that further collections within Solomon Islands would increase the number of recorded species, expand their range, and lead to a rearrangement of their taxonomy (Whitmore 1966; Chaplin 1988; Leenhouts, P.W. 1989, pers. comm.).

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1 See Terminology (2.1.2) page 6.

2 Male and female flowers found on separate trees.

Table 1. *Canarium* **collected** in Solomon Islands.

Species/ssp/var	Common synonym/ [misidentification]	Common names	Status in SI[1]	Distribution	Taxonomy[2] Sect	grp	Notes
1. ***indicum*** L.	*commune* L. *mehenbethene* Gaertn. [*vulgare* auctt., — non Leenh.]	kenari Java almond galip (PNG) tulip wood			Can	Vul	
var. *indicum*		ngali(SI) nangai (Van.)	Co/Cu	Indonesia PNG/SI Vanuatu			**kernel edible** fimbriate-persistant stipules
2. ***salomonense*** Burtt.							
ssp. *salomonense*		Andoa(SI)	Co/Cu/W	Bougainville SI	Can	Mal	**kernel edible**
3. ***harveyi*** Seem.	*sapidum* Hems.			SI/Vanuatu Fiji/Tonga Samoa	Can	Mal	taxon. unclear
var. *nova-hebridiense* Leenh.		Santa Cruz nut	U/Cu	SI (S.Cruz) N. Vanuatu			**kernel edible**
			R/W	SI			**kernel edible**
var. *sapidum* (Hems.) Leenh.							
4. ***hirsutum*** Willd.	*palawense* Laut.			Malaysia Indonesia	Pim	Hir	
ssp. *hirsutum*							
var. *hirsutum*			U?	Malaysia SI/PNG			fruit prickly/hairy
ssp. *multicostulatum*	Leenh.						
var. *leeuweni* Leenh.			U?	SI/PNG			i.d. doubtful
5. ***asperum*** Benth.	commune (non L.) + 20 others			Malaysia Indonesia Philippines SI/PNG	Pim	Asp	v. variable
ssp. *asperum*							
var. *asperum*			Co/W	— " —			
6. ***vitiense*** A.Gray	*samoense* Engl. *schlechteri* Laut. *smithii* Leenh. *bacciferum* Leenh. [*acutifolium* Merril var. *aemulans* (Laut) auctt. non Leenh.]		Co/W	PNG/SI Fiji Samoa Tonga Australia	Pim	Asp	mesocarp edible v. close to 8.
7. ***liguliferum*** Leenh.			R	SI	Pim	Asp	
8. ***vanikoroense*** Leenh.	*linguistipulum* Leenh.		U	Vanikoro Banks Is. Fiji	Pim	Asp	

Source: Leenhouts (1955, 1956, 1959, 1965, 1972a, 1976); Whitmore (1966); Hewson (1985); Yen (1985, 1991); Hancock and Henderson (1988).
Notes: 1. Co = common; U = uncommon; R = rare; Cu = cultivated; W = wild
2. See note 2, Table 2 (next page).

Table 2. *Canarium* **possibly** in Solomon Islands.

	Species/ssp/var	Common synonym/ [misidentification]	Common names	Status[1] in SI	Distribution	Taxonomy[2] Sect grp	Notes
1.	***vulgare*** Leenh.	*commune* L. [*indicum* auctt. non L.]	Java almond kenari	R?	Malaysia Indonesia	Can Vul	entire-caducous stipules BSIP2155-(no stipules) **kernel edible**
2.	***chinare*** Grutt. and Lam			R?	Bougainville	Pim Asp	v.close to- *vitiense* *liguliferum* *vanikoroense*
3.	***acutifolium*** Merril.				E. Indonesia PNG	Pim Asp	v.close to- *vitiense* *liguliferum* *vanikoroense*
	var. *acutifolium*			R?	W. PNG		

Source: Leenhouts (1955, 1956, 1959, 1965); Whitmore (1966); Hancock and Henderson (1988).
Notes:
1. Co = common; U = uncommon; R = rare; Cu = cultivated; W = wild
2. After Leenhouts (1959, 1972a):

Genus	Section	Group	Features
Canarium	*Canarium*	Canarium	Stipules flat or auricle shaped
		maluense	Stipules auricle shaped 2 or 3 fruit cells sterile, strongly reduced
		vulgare	Large stipules at conjunc. of petiole/branchlet
	Pimela	hirsutum	v. variable
		asperum	Stipules subulate pistil in male fls. strongly reduced

2.1.2 Terminology (Figure 1, Plate 1)

Fruit

A drupe (fleshy indehiscent fruit). Generally, the skin (exocarp)[3] is green when unripe, black when ripe. When mature the edible, but rather astringent, flesh (mesocarp) quickly deteriorates due to rotting, dehydration and/or insect attack making measurement of variation in fruit shape, skin and flesh colour unreliable for taxonomic purposes.

Variation in fruit shape, skin and flesh colour.

Nut-in-shell (NIS)

The expression 'nut-in-shell' (NIS) is preferred to that of 'nut' which lacks a clear non-botanical definition. The shell (endocarp)[4] originates from the innermost walls of the ovary and is, therefore, a maternal characteristic. The shape (less so than size), particularly the cross section of the NIS, is perhaps the most stable characteristic of the fruit.

Variation in shape, size, cross-section.

Kernel-in-testa (KIT)

Edible, non-endospermic seed consisting of two intimately entwined cotyledons enclosed in a protective testa. The testa is made up of a leathery exterior (white when mmature, usually brown/mottled red with black veins when mature) tightly fused with a thin, transparent membrane (Corner 1976).

Variation in testa colour, number and shape of cotyledons.

Stipules

Non-photosynthetic leaf-like appendages at or near the base of the petiole, thought to originate from a reduced basal pair of leaflets and/or petiolules. In *Canarium*, there are two main types: subulate (awl shaped, narrow, pointed) and; flat/auricle (heart shaped) (Leenhouts 1959).

Variation in presence/absence, persistence, shape and size.

2.1.3 Field description of edible Solomon Islands species[5]

Canarium indicum L. var. *indicum* ngali nut

TREE large (up to 40 m), broad (up to 1.5 m dbh), planted, dense crown

LEAVES pinnate, 4–10 pairs of leaflets

STIPULES large (up to 100 × 50 mm), conspicuous, persistent, located at the conjunction of the branch and petiole, ovate with fimbriate-dentate margins

NIS 3–6 sided/rounded, 1 (sometimes 2 or 3) kernels, sterile cells mostly reduced (Figure 1, Plate 1a).

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[3] Lam (1931, 1932) and Leenhouts (1956, 1959) do not refer to the outermost epidermal skin layer choosing to describe the flesh as the pericarp and the shell (pyrene) as the mesocarp plus endocarp. Ng (1991) names the flesh as the outer mesocarp and the hard shell as the inner mesocarp. These descriptions are dropped in favour of the more usual interpretation of the fleshy part of a drupe being the mesocarp, and the hard shell the endocarp (Tootill 1984, Wannan and Quinn 1990, Coronel 1991). See also Sect. 4.6.1 and Figure 10.

[4] The shell is made up of three bonded layers, the size and arrangement of which can have an effect on the strength of the shell (Juliano 1936).

[5] Source: Leenhouts (1959); Whitmore (1966); Chaplin (1988) and authors field notes.

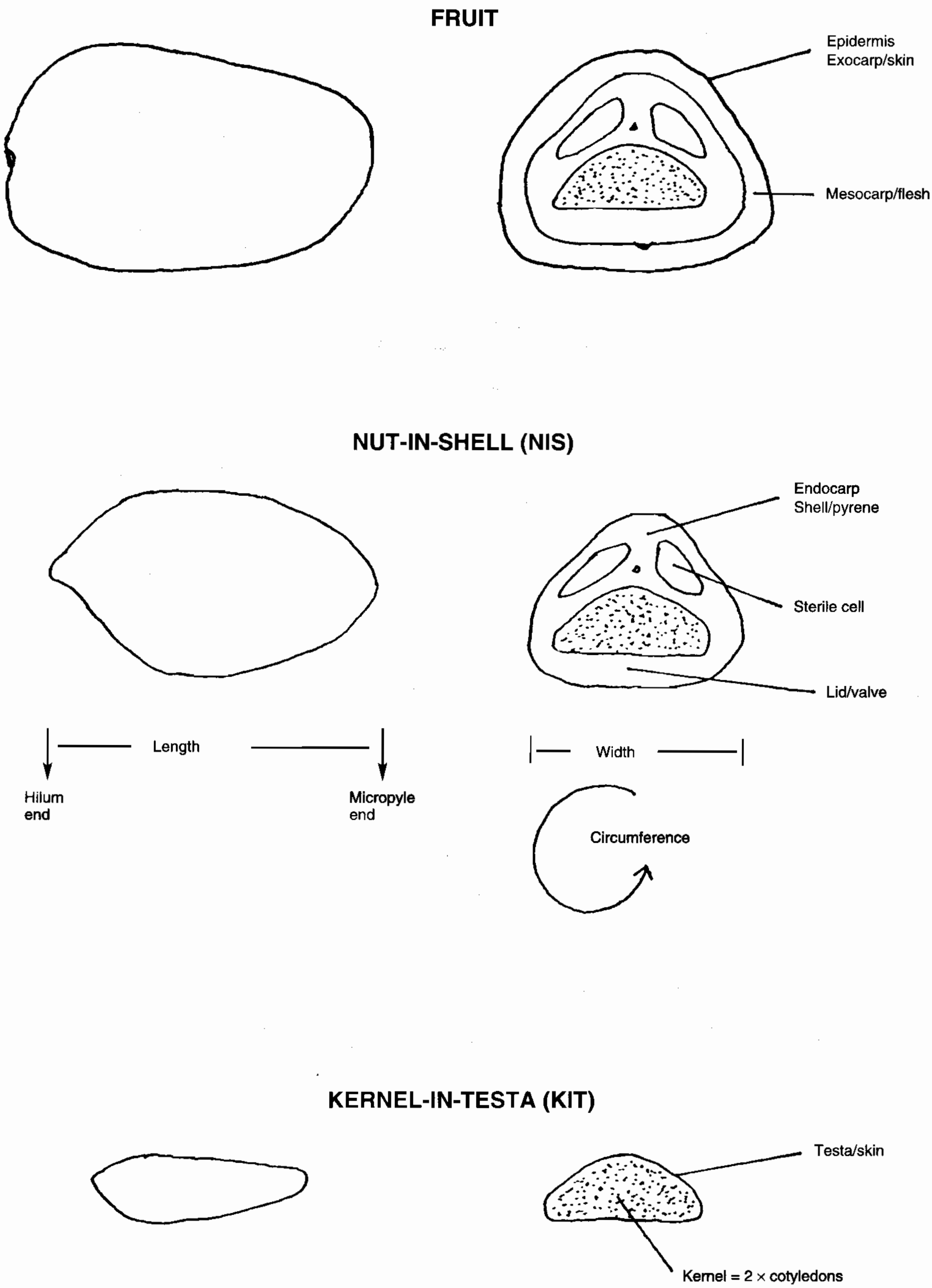

Figure 1: Morphology of *Canarium indicum* var. *indicum* fruit (× 1). (Ref: BARA1, New Georgia)
Note: exocarp + mesocarp + endocarp = pericarp.

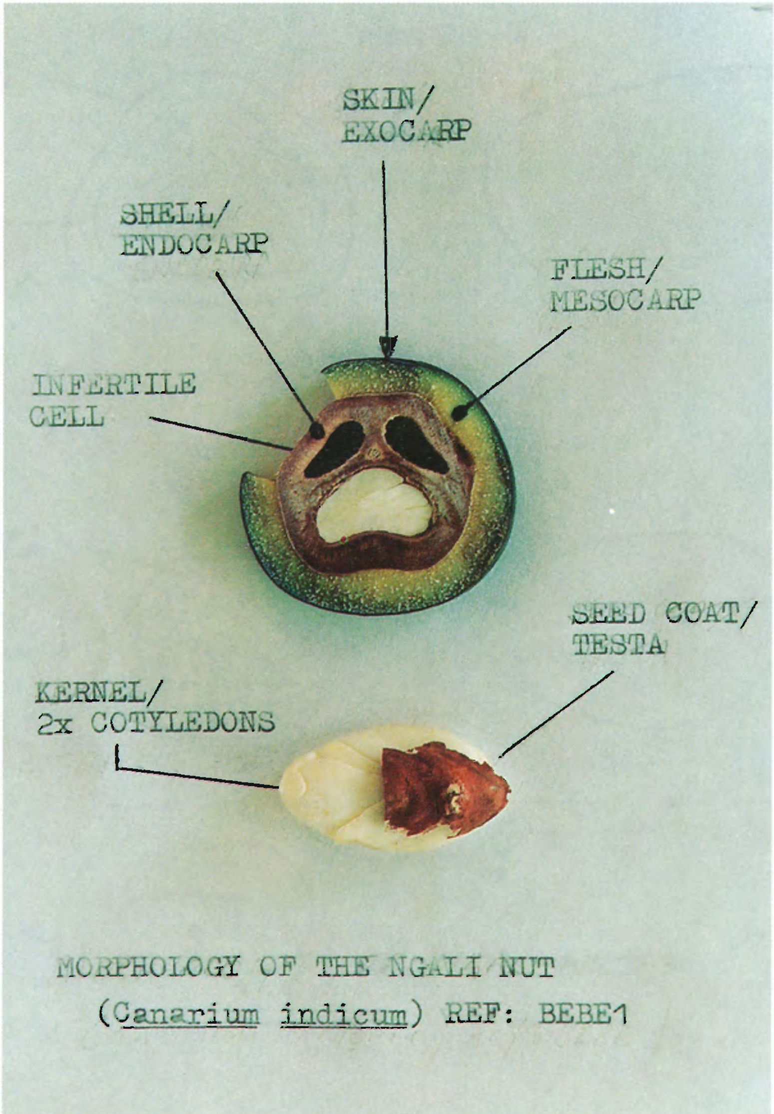

Plate 1A: Morphology of *Canarium indicum* var. *indicum* *'ngali nut'* (× 0.75).

Plate 1B: Morphology of *Canarium harveyi* var. *nova-hebridiense* *'Santa Cruz nut'* (× 0.6)

Canarium salomonense Burtt. ssp. *salomonense* andoa/wild nut

TREE wild, sometimes planted, up to 30 m

LEAVES pinnate, 2–4 pairs

STIPULES very small (c. 5 × 5 mm), rounded to auricle (heart) shaped, subpersistent, inserted on petiole 10–30 mm from base

NIS 2 sided/round, small, smooth, ovate, 1 kernel (very rarely two), sterile cells strongly reduced.

Canarium harveyi Seem. var. *nova-hebridiense* Leenh. Santa Cruz nut

TREE cultivated, open crown, rarely greater than 30 m

LEAVES pinnate, 2–4 pairs, often falling off at fruit maturity

STIPULES small (c. 10 × 10 mm), auricle shaped, caducous (falling off), inserted on petiole 5–20 mm from base, distinctive twin scars after falling off

NIS 2 sided/round, often with ridges, large, ovate, 1 kernel, sterile cells strongly reduced (Plate 1b).

2.2 *Terminalia*

2.2.1 Taxonomy

Terminalia belongs to the family Combretaceae (18 genera, c. 450 species) which is found throughout the tropics and subtropics. *Lumnitzera* is the only other genus belonging to Combretaceae found in Solomon Islands (Hancock and Henderson 1988).

The comparative taxonomy of Terminalia is based primarily on fruit morphology (Coode 1969, 1978).

Fifteen species of *Terminalia* are reported in the Solomon Islands (Table 3). A number of these are important native and exotic timber species.

Two species in Solomon Islands are known to have edible kernels: *T. catappa* and *T. kaernbachii*. Coode (1978) notes that the kernel of *T. copelandii* (a close relative of the latter species) may be edible, but this has not been confirmed in other literature.

The flesh of *T. solomonensis* is reported as edible by Whitmore (1966), but Chaplin (1985) quoting Coode in personal communication states that the local kwar'ae name of 'To'oma' refers 'without reasonable doubt' to *T. megalocarpa*. Henderson and Hancock (1988) subsequently identified *T. solomonensis* as edible, but they were unaware of Chaplin's paper (Henderson pers. comm.). Furthermore, their description of the fruit matches that for *T. megalocarpa*. This confusion is undoubtedly caused by the similarity of the two species and by the human cultivation of *T. megalocarpa* for its edible fruit in Solomon Islands (Coode 1978).

T. impediens Coode, which has a very similar fruit to *T. kaernbachii* (but distinguishable by having unequal halves [Coode 1969]), may also have been introduced to Solomon Islands from its native PNG because of its large edible kernels (Chaplin 1985)[6], but there is no record of its being collected.

6 Although they are generally smaller than *T. kaernbachii* (Howcroft 1992).

Table 3. *Terminalia* in Solomon Islands.

	Species/ssp/var	Common synonym/ [misidentification]	Common names	Status in SI[1]	Distribution	Notes
1.	***catappa*** L.		Sea almond Indian almond	Co/Cu/W	Worldwide	**kernel edible**
2.	***kaernbachii*** Warb.	*okari* C.T.White	okari nut	R/Cu	PNG/SI	introduced from PNG **kernel edible**
3.	***brassii*** Exell	*kajewskii* Exell	Swamp oak	Co/W	Bismarks/SI	timber
4.	***calamansanai*** (Bl.) Rolfe	 *latialiata* C.T.White		Co/W	SE Asia PNG/SI	timber
5.	***complanata*** K.Sch.			U/W	PNG/SI/Aust.	variable
6.	***copelandii*** Elm.	*catappoides* C.T.White and Francis		Co?/W	Indonesia Philippines PNG/SI	kernel edible?
7.	***ivorensis*** A.Chev			R	W. Africa	plantation timber
8.	***megalocarpa*** Exell	[*solomonensis* auctt., non Exell]		Co/Cu	PNG/SI	flesh edible
9.	***microcarpa*** Decne ssp. *microcarpa*	 *foveolata* White and Francis *hypargyrea* K.Sch. and Laut.		 R/W	 PNG/SI	 BSIP17542-v. doubtful
10.	***rerei*** Coode			U/W	SI	endemic?
11.	***samoensis*** Rech.	*saffordii* Merr.		U?/W	PNG/SW Pacific	
12.	***sepicana*** Diels.			U/W	PNG/SI/Van.	**kernel edible**/timber
13.	***solomonensis*** Exell	*lundguistii* Exell *papuana* Exell		Co/W	PNG/SI	
14.	***superba*** Engl. and Diels			U	Africa	plantation timber
15.	***whitmorei*** Coode	[*steenisiana* auctt., non Exell]		U/W	SI	endemic

Source: Whitmore (1966); Coode (1969, 1978); Hancock and Henderson (1988).
Notes:
1. Co = common; U = uncommon; R = rare; Cu = cultivated; W = wild.

2.2.2 Terminology (Figure 2, Plate 2a)

FRUIT — A fibrous drupe. The pericarp is made up of a usually thin fleshy exocarp; a thin, tightly woven/matted fibrous (often undeveloped) mesocarp; fused tightly with a thick, hard, often pitted-ridged, endocarp (stone).

Variation in shape, colour of fruit; cross section of stone

KIT — Edible, non-endospermic single seed consisting of 2 (4) rolled cotyledons enclosed in an inconspicuous cream coloured (sometimes red) testa.

Variation in testa colour, number and design of cotyledons.

2.2.3 Field description of edible Solomon Islands species[7]

Terminalia catappa L. — alite nut

TREE — medium broad (mostly 10–20 m) often with buttresses, deciduous (rarely without some leaves red), 'Terminalia' (Pagoda-like) branching. Found mostly near to the sea.

LEAVES — usually sub-cordate at base

FRUIT — small (up to 70 × 40 mm), flattened with flange (minor wings), green turning red when mature. Two cotyledons (Figure 2).

Terminalia kaernbachii Warb. — bush alite nut

TREE — 20–30 m, usually straight bole, planted, mostly inland, conspicuous Terminalia branching

LEAVES — cuneate (sharp) at base, petioles c. 2 cm[8], underside of leaf and petiole with persistent reddish-brown hairs

FRUIT — large (up to 100 × 70 mm) red-purple when mature, splits in to two equal halves[9] when cut. Four (or more?) cotyledons (Plate 2a).

2.3 *Barringtonia*

2.3.1 Taxonomy

Barringtonia belongs to the family Lecythidaceae, a large, mainly nut-bearing, family of trees which includes other well known nuts such as the Brazil nut (*Bertholettia excelsa*) and the so-called monkey pot trees (*Lecythis* spp.). In Solomon Islands, *Gustavia* is the only other genus of Lecythidaceae present (Hancock and Henderson 1988).

The comparative taxonomy of *Barringtonia* is based primarily on floral morphology, particularly the structure of the calyx (see terminology below) in the mature bud and the design of stamens and staminodia (fertile and sterile male reproductive organs of flower respectively) (Payens 1967).

Seven species of *Barringtonia* have been reported from Solomon Islands (Table 4). Three species—*B. procera*, *B. edulis* and *B. novae-hiberniae*—have edible kernels.

Yen (1974) identified *B. procera* as the most common cut nut in Temotu and Solomon Islands.

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7 Source: Whitmore (1966); Foreman (1971); Coode (1978); Chaplin (1985); Henderson and Hancock (1988).

8 Sessile in *T. copelandii*.

9 Unequal in *T. impediens*.

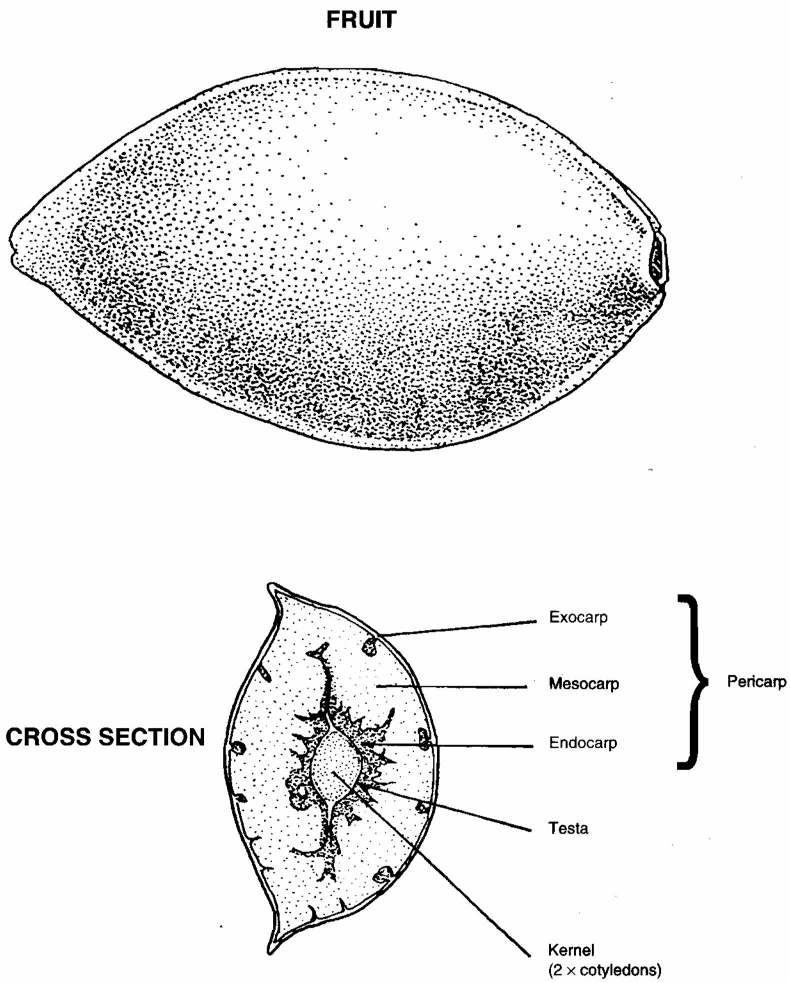


Figure 2: Morphology of *Terminalia catappa* fruit (alite nut) (× 1). (Photo: G. Chaplin)

In Payens' (1967) monograph of the genus, the distribution of *B. edulis* is given as Fiji only, but it has been persistently recorded in Solomon Islands (Whitmore 1966; Henderson and Hancock 1988) and is common in parts of PNG (Jebb 1992) and Vanuatu (Walter and Sam 1990, 1992a). The *B. edulis* collected from the Solomon Islands before 1965 were subsequently determined by Payens as either *B. procera* or *B. novae-hiberniae*. However, Smith (1981) and more recently Jebb (1992) has pointed out that Payens confused the identity of *B. edulis* with *B. seaturae* Guppy and that the first collections of *B. edulis* were in fact taken from Vanuatu.

This confusion is due to the similarity of *B. edulis* to the other two edible species and is probably further confounded by the cultivation of all three species.

2.3.2 Terminology (Figure 3, Plate 2b)

FRUIT — A fibrous drupe. The pericarp consists of a fleshy exocarp, a thin fibrous mesocarp and a hardened thin endocarp.
Variation in fruit shape, skin and flesh colour, thickness and configuration of pericarp parts.

KIT — Single edible, non-endospermic, often fissured, seed covered by a thin minutely tomentose (hairy) testa.
Variation in shape, testa colour

CALYX — Outermost protective part of bud (later flower) made up of a whorl of leaf-like sepals. In *Barringtonia*, the calyx in bud is either: closed; open with apical pore (rupturing in to pseudo-lobes); or open with free lobes (Payens 1967).
Variation in size and margin of apical pore in bud

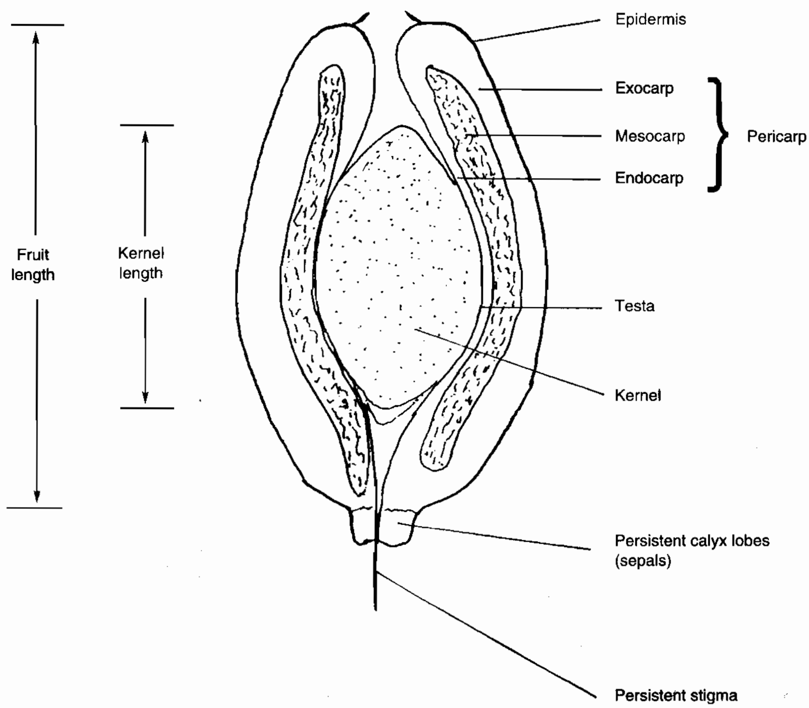


Figure 3: Morphology of *Barringtonia procera* fruit (cut nut) (× 1).

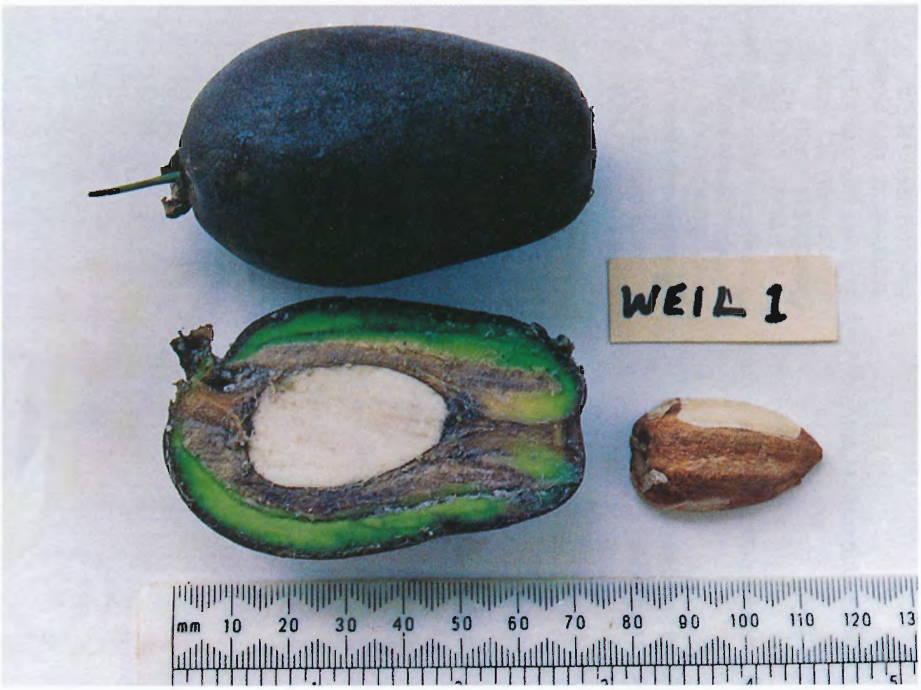
Table 4. *Barringtonia* in Solomon Islands.

	Species/ssp/var	Common synonym/ [misidentification]	Common names	Status in SI[1]	Distribution	Notes
1.	***asiatica*** (L.) kurtz	*littorea* Oken		Co/W	World wide	seed = fish poison
2.	***procera*** (Miers) Knuth	*guppyana* Knuth *magnifica* Laut. *schuchardtiana* K.Sch. [*edulis* auctt., non Seem.]	cut nut	Co/Cu	PNG/SI/ Vanuatu	**kernel edible**
3.	***novae-hiberniae*** Laut.	*brosimos* Merr. and Perry *excelsa* (non Bl.) Guill. *oblongifolia* Knuth [*edulis* auctt., non Seem.]	cut nut	Co/Cu/W	PNG/SI/ Vanuatu	**kernel edible**
4.	***niedenzuana*** (K. Sch.) Knuth	*araiorhachis* Merr. and Perry *bougainvilleana* Knuth *quadrigibbosa* Laut.		C/W	PNG/SI	inedible
5.	***racemosa*** (L.) Spreng	*salomonensis* Rech.		Co/W	World wide	inedible
6.	***edulis*** Seem.	*seaturae* (non Guppy)- *sensu* Payens (1967)	cut nut	Co?/Cu[2]	PNG/SI/ Vanuatu/ Fiji	**kernel edible**
7.	***samoensis*** A.Gray[3]	*rubra* [non (Pers.) Bl.] Miq. [*racemosa* auctt., non (L.) Spreng]		?	PNG Micronesia Samoa Is.	inedible

Source: Payens (1967); Hancock and Henderson (1988).
Notes
1. Co = common; U = uncommon; R = rare; Cu = cultivated; W = wild.
2. Whitmore (1966).
3. From single specimen in Honiara herbarium (BSIP12338) det. Leiden 1970.

A.

Plate 2: **A.** *Terminalia kaernbachii* (× 0.5)
B. *Barringtonia procera* (× 0.75)



B.

2.3.3 Field description of edible Solomon Islands species[10]

Barringtonia procera (Miers) Knuth — cut nut

TREE	Slender, sparsely branched, heavily flowered/fruited, commonly planted in villages.
LEAVES	large (29–55 × 8–24 cm), very glossy, margin serrate-crenulate (wavy), (sub)sessile.
FLOWERS	(sub)sessile, calyx closed in bud-rupturing in to 2–4 lobes.
FRUIT	purple, long (6–7.5 × 3–4 cm), cylindrical, 8-sided (more prominent with exocarp removed?), hooked near the base (Figure 3, Plate 2b).

Barringtonia novae-hiberniae Laut. — bush cut nut

TREE	slender branched
LEAVES	13–40 × 5–12 cm, petiole 2–5 cm, margin near entire, base cuneate or acute.
FLOWERS	pedicelled (2–10 mm), calyx open in bud with large apical hole.
FRUIT	6–15 × 2–7 cm, shortly pedicelled, green or purple, broad obovoid, tapering at base.

Barringtonia edulis Seem. — cut nut

TREE	small (6–15 m), dbh 30–40 cm
LEAVES	17–45 × 11–20 cm, petiole 5–10 mm
FLOWERS	pedicelled (2–10 mm), bud with mucro (small fine point), calyx closed in bud, disrupting into 2–3 elliptic obtuse lobes.
FRUIT	green, fleshy, 4.5–5 × 1.5–2 cm, tomentose (dense short fine hairs), cylindrical.

2.4 Review of literature and similar work

Compared to its neighbours, Solomon Islands is poorly represented in botanical literature; Merrill (1981) describes the country as botanically 'terra incognita'. Few comprehensive studies of its flora have been made, even less of particular types of plant such as fruits and nuts.

The first survey of Solomon Islands forests was carried out in the 1940s by Walker (1948). This was followed by a more detailed and systematic description by Whitmore (1966) based on a nationwide field collection over 2 years. Whitmore found seven species of *Canarium* in Solomon Islands, including a new endemic species, *C. liguliferum* Leenh., and also noted the widespread variation in fruit shapes within *C. indicum* due to cultivation.

Whitmore's work was further expanded to include herbaceous, ornamental and crop plants by Henderson and Hancock (1988) in a comprehensive ethnobotanical survey of the whole Solomon Islands. This work included a brief description of a number of fruit cultivars of *Barringtonia edulis* and *B. procera* and details of the edible *Canarium* and *Terminalia* spp. found in Solomon Islands. A Solomon Islands flora checklist was also published separately (Hancock and Henderson 1988).

[10] Source: Payens (1967); Smith (1981).

Yen (1974), in a study of the arboriculture of the Santa Cruz Islands, described numerous forms of what he later identified as *Canarium harveyi* var. *nova-hebridiense* Leenh. (Yen 1985). Yen (1990, 1991 and 1993) and others (Kirch 1989; Lepofsky 1992) have used *Canarium* shells from archeological excavations to help trace the biogeography and ethnography of the area.

The Forest Research Department in Solomon Islands have a number of on-going field trials involving *Canarium* (Forestry Division 1991) and have previously studied the status, yield and silviculture of *Canarium indicum* and *C. salomonense* (Chaplin 1988; Chaplin and Poa 1988). Chaplin (1985) has also summarised the current status of *Terminalia kaernbachii* in Solomon Islands.

The Tree Crops Section in the Research Division of the Ministry of Agriculture and Lands in Solomon Islands have also collected *Canarium*, *Terminalia* and *Barringtonia* in the past, some of which are planted at Tenaru Field Experimental Station (FES) on Guadalcanal.

A number of publications based on work carried out in neighbouring countries have included ENTC found in Solomon Islands.

Peekel (1984) described a number of *C. indicum* and *C. salomonense* fruit forms found in the Bismarck archipelago of PNG.

Smith's (1981, 1985) comprehensive and authoritative 'Flora Vitiensis' has a description and key to the species of *Canarium*, *Barringtonia* and *Terminalia* found in Fiji.

Brief species descriptions can also be found in a recent analysis on the economic potential of indigenous and other ENTC found in the S. Pacific (Carlos and Dawes 1990).

The on-going Plant Resources of Southeast Asia (PROSEA) project has descriptions of some of the edible *Canarium* and *Terminalia* spp. found in Solomon Islands (Johns 1991; van Valkenburg and Waluyo 1991).

In the Philippines, the previously economically important pili nut (*Canarium ovatum* Engl.) has been studied by a number of workers from the University of the Philippines. Gonzales and Bunoan (1947) and Coronel and Zuno (1980a, 1980b) both studied the fruit characteristics of pili cultivars, while Juliano (1936) made a detailed morphological study of the nuts' shell. The horticulture of Pili has been studied by Tolentino (1986) and its floral morphology by Linsangen et al. (1979). General overviews are given by Coronel (1983, 1991).

A surprising amount of work is currently being carried out on ENTC in the southwest Pacific.

Dr Matthew Jebb of the Christensen Research Institute in Madang has reviewed the taxonomy of edible *Barringtonia* in PNG (Jebb 1992).

The Lowland Agriculture Station at Keravat in East New Britain, PNG has a collection of ENTC from around PNG (Aburu 1982). In 1991, a survey of *Canarium indicum* cultivars in the Gazelle peninsula was carried out by LAES, but the results have not been collated or written (Moxon pers. comm.).

In Vanuatu, the Forest Department has collected *Canarium*, *Terminalia* and *Barringtonia* as part of a forest inventory (Gowers 1976; Wheatley 1992). A detailed account of indigenous edible fruit and nut species is presently being carried out by the French government financed ORSTOM research organisation (Walter and Sam 1990, 1992a, 1992b; Walter, Sam and Mabonlala 1993; Walter and Mabonlala 1993).

The taxonomy of *Canarium*, *Barringtonia* and *Terminalia* are detailed in monographs by Leenhouts (1955, 1959), Payens (1967) and Coode (1969, 1978) respectively. Only in the latter genus, *Terminalia*, was mostly live field material studied; Leenhouts and Payens both relied almost exclusively on (often inadequate) dried herbaria material (Leenhouts pers. comm.).

2.5 Other edible nuts in Solomon Islands

This report deals only with three edible tree nut producing genera. There are, however, many more indigenous nuts eaten in Solomon Islands which have not been studied in detail but which warrant a brief description here.

Although commonly referred to as nuts, botanically most are other types of fruit (such as drupes, berries, syncarps and legumes); the botanical definition of a nut being restricted to 'a hard indehiscent one seeded fruit' (Jackson 1928). However, most of the species below are included in the 100 plus species described by Duke (1989) as nuts or are referred to as nuts by Henderson and Hancock (1988) and are, therefore, included here for sake of completeness.

Areca catechu L. Betel nut — Arecaceae

A well known slender erect palm which can grow up to 30 m. Solomon Islands is the eastern border of the betel nut chewing zone which extends westwards as far as W. Asia. Common throughout Solomon Islands, with many cultivars.

The fruit is a nut with a endospermic seed/kernel enclosed in a thin testa and hard fibrous pericarp. The kernel is normally chewed in combination with lime (made from crushed coral) and Pepper leaf (*Piper betle* L.).

Castanopsis acuminatissima (Bl.) A. DC PNG oak — Fagaceae

Oak like tree, which is a traditional forest food in PNG (Merril 1945, May 1984), possibly in Solomon Islands (Henderson and Hancock 1988). The seeds are generally boiled before eating (French 1986).

Castanospermum australe Cunn. and Fraser ex Hook — Fabaceae

Moreton Bay chestnut, Black bean tree.

A native of Australia and New Caledonia, according to Henderson and Hancock (1988) introduced to Solomon Islands in the past 50 years as a export timber and ornamental. The fruit is a leguminous pod with 2–6 chestnut brown seeds. The seeds are only edible after prolonged soaking and roasting (Duke 1989).

Finschia waterhousiana Burtt — Proteaceae

'Akama' (Kwara'ae[11])

Common tree with prominent stilt roots and bright orange pendulous inflorescences. Also found in PNG (Foreman 1971, Henderson and Hancock 1988). The raw kernels are eaten as a bush snack throughout Solomon Islands.

[11] Kwara'ae (from N. Malaita) is the *de facto* plant naming language in Solomon Islands. See section 4.4 for more details.

Gnetum **spp.** Gnetaceae

G. gnemon L. (King tree, 'Dae Fasia' [Kwara'ae]) is a relatively small, common, lowland forest, mainly dioecious tree found in Solomon Islands as well as most of the southwest Pacific and southest Asia. In Temotu province, there are a number of cultivars.

In Solomon Islands (especially in Temotu), the cooked leaves, mesocarp and seed from mostly cultivated trees are eaten (Henderson and Hancock 1988).

G. latifolium Bl., a common thick woody forest climber which is frequently used as a climbing vine in Solomon Islands, also has seeds which are edible after roasting (Henderson and Hancock 1988; Borrell 1989).

Haplolobus floribundus (K. Sch.) Lam. Burseraceae

ssp. *salomonensis* (C.T. White) Leenh.

'Gemugi' nut (Rennell), 'Mala Adoa' (Kwara'ae)

An uncommon (except in Rennell) medium height forest tree, similar in appearance to *Canarium salomonense* (hence the Kwara'ae name Mala Adoa = like *C. salomonense*), but distinguishable by its lack of stipules, thin soft shelled NIS and flat oak-like cotyledons (Whitmore 1966, Henderson and Hancock 1988, Leenhouts 1972b). The classification of Gemugi nut is unclear because of the non-specific Kwara'ae name, intra-species variation through selection, and the genus' complicated taxonomy; in the most recent revision of the genus, Leenhouts (1972b) divides *H. floribundus* in to four subspecies and ssp. salomonensis in to var. *salomonensis* and var. *hirsutus* Leenh.

The fruit is a drupe, with an edible mesocarp (after boiling) and kernel-in-testa which must be soaked in water for several weeks to remove its bitterness and toxicity before being eaten alone or mixed with vegetables in a soup, etc. Only in Rennell is the seed from this tree eaten (Henderson and Hancock 1988).

Inocarpus fagifer (Park) Fosb. Fabaceae

Polynesian or Tahitian Chestnut

syn. *I. fagiferus* (Park) Fosb., *I. edulis* Forst.

Second storey leguminous lowland-seaside forest tree found throughout Solomon Islands. Common in the Pacific and southeast. Asia.

The fruit is a large, green indehiscent pod with a single seed which must be cooked (usually roasted in Solomon Islands) in or out of the pod before eating (Smith 1985; Henderson and Hancock 1988).

Omphalea queenslandiae F.M. Bail Euphorbiaceae

syn. *O. gageana* (Pax and Hoffm.) Airy Shaw, *O. papuana* Gage, and others

'Kwalo Falake' (Kwara'ae)

Uncommon large woody climber with distinctive 3–5 lobed palmate juvenile leaves and basal lobes (like *citrus* spp.) on mature leaves.

Fruit has three edible seeds (raw or cooked) enclosed in a thin fleshy mesocarp and a thin ridged-undulating woody shell (Henderson and Hancock 1988).

***Pandanus* spp.** 'Screw pines' Pandanaceae

A small sometimes large dioecious monocotyledon shrub or tree found throughout the Pacific; in the Solomon Islands typically found on the coast or inland garden sights.

The taxonomy of *Pandanus* spp. in the southwest Pacific is still far from clear (Massal and Barrau 1956; Smith 1979; Stone 1988), but the most common edible species in Solomon Islands is probably *P. dubius* Spreng. with numerous other species and cultivated forms being eaten locally (Stone 1972, 1973, 1976; Yen 1974). Henderson and Hancock (1988) tentatively identified their survey specimens from Malaita and Temotu provinces as *P.* aff. *compressus* Martelli a synonym of *P. dubius* Spreng. var. *compressus* (Martelli) Stone.

The fruit is a syncarp (formed from united carpels) which can grow up to 30 cm in diameter containing 50 or more fibrous segments each with 2–4 edible seeds which can be eaten raw or roasted.

The leaves of most *Pandanus* spp. are used as handicraft, furniture and building materials.

Pangium edule Reinw. Flacourtiaceae

'Pang' (Indonesian), 'Falake/Ra' (Kwara'ae)

Tree, uncommon in Solomon Islands (?), sometimes planted (Henderson and Hancock 1988).

The fruit has a number of hard woody seeds surrounded by a soft endosperm all enclosed in a bright yellow mesocarp and green skin.

According to Henderson and Hancock (1988) the kernels are not eaten in Solomon Islands except in Ngatokae (East Marovo, Western Province). In PNG the kernels are eaten after boiling and soaking to remove the cyanogenetic glucosides (May 1984).

3. METHODS

3.1 Introduction

3.1.1 What is a superior variety?

In this survey, the definition of a superior variety was made as flexible as possible to describe any tree or nut with noTable botanical, economic or agronomic characteristics. In the vast majority of cases recorded, trees/nuts were not *botanical* varieties, but rather fruit forms. A broad definition of a superior variety was given as a guide.

A superior variety was described as having one or more of the following characteristics:

1. high kernel/nut ratio (in turn a function of NIS weight and KIT weight);
2. high yields;
3. easy opening fruits/shell;
4. thin shell;
5. good taste;
6. no major pest and disease problems.

3.1.2 Identification

Potential superior varieties were identified with the help of local people. Meetings were held in villages, where the local people were asked to describe any 'big', 'special' or 'unusual' nuts in their area. Frequently, there were examples of the nuts stored in kitchens. A decision was then made whether or not to visit the tree. *The collection was not, therefore, randomly selected and hence the data should be treated accordingly.*

3.2 Data collection and analysis

3.2.1 Areas visited

The following islands were visited, often more than once, between July 1988 and December 1991:

Province	**Island**
TEM	Nendo (Santa Cruz) and Reef Is.
MAK	San Cristobal and Santa Ana
GC	Guadalcanal
MAL	N. and S. Malaita
ISA	Santa Isabel
WP	E. New Georgia (Marovo islands), W. New Georgia, Rendova, Tetepare, Kolombangara, Gizo, Simbo, RanGanongga, Vella Vella, Choiseul and Shortlands

In the majority of cases, each island was circumnavigated by sea, with stop-offs at selected villages. More than 100 villages were visited in total. Central Island Province (CIP) was not visited. The Florida Islands, which belong to CIP, can be expected to be botanically identical to their very close neighbours MAL and GC, but the isolated Rennell and Bellona polynesian islands are well known to have many endemic species and varieties (Henderson and Hancock 1988).

3.2.2 Field data

The following data were collected (summary only):

1. ACCESSION/ REFERENCE No:	A simple meaningful reference code was used based on the first four letters of the nearest major village to where the tree was located. Trees were tagged for future identification.
2. TREE DATA:	Location and owner of tree. Species/variety/form. Local name/language/meaning of name. Local distribution/frequency. Height/dbh/estimated age. Crown width/shape. Origin: planted or wild. Bark colour. Fruiting period/frequency. Distinguishing characteristics. Leaf length/width/blade/shape/margin/type.
3. FRUIT DATA:	Length/width/circumference/shape of: Fruit, NIS and KIT. Colour of skin/flesh/shell/testa. Ease of opening NIS (1–5, 5 = very easy). Kernel taste: (1–5, 5 = very tasty/sweet).
4. PRESSING	Limited to a few specimens of special. Taxonomic interest.

3.2.3 Laboratory data and analysis

1. WEIGHT ANALYSIS:

   Fruit, Flesh, NIS, Shell, KIT } weight and percentage weight

   Kernel m.c. (dried at 100 °C for 3 hours).
   K:N ratio (percentage weight of NIS [<5% m.c.] that is, dry.
   KIT [<1% m.c.]).
   Percentage of NIS with 2 or more kernels.

2. OIL ANALYSIS:
   Selected varieties were also tested for:
   Oil content.
   Free fatty acid content.
   Fatty acid composition.

3. PHOTOGRAPHS: NIS and cross section of NIS

4. RANK: Each variety of *Canarium* was ranked using a combination of data:

RANK = Ease of opening NIS (1–5).
+ (NIS length[mm])/10) (1–5).
+ (K:N ratio/5) (0–6).
+ Distinguishing character (0–5).

1 = not important.
2 = minor importance.
3 = important.
4 = very important.
5 = extremely important.

The higher the score, the higher the rank. Where data were unavailable, the average for the species was used.

5. CORRELATION: NIS length, width, circumference and weight were tested for correlations with NIS weight, KIT dry weight and K:N ratio.

3.2.4 Records

All data were recorded on paper using a standard record sheet and copied to a computer database using Dbase 3+. Each tree was tagged for future identification. Where possible, seed was collected for propagation and subsequent planting out at Field Experimental Stations (FES) around the country (records of which are kept at DCRS).

4. RESULTS

4.1 Introduction

Records were taken of 97 trees (specimens) from around Solomon Islands (Table 5)[1]. More than 200 trees were observed in detail, but many were not recorded, mainly because they were duplicates of fruit forms already collected or they were judged to be of no taxonomic interest. The bias towards collection in the Western Province (WP) and Temotu Province (TEM) reflects the importance and often intensive cultivation of nut trees (*Canarium* in particular) in those provinces.

In a significant number of cases it was impossible to collect all data, mainly because insufficient fruits were available at the time. However, data collection is still continuing.

The main characteristics of each specimen collected are given in Appendix 1.

Table 5. Number of specimen trees recorded in edible nut tree variety collection, Solomon Islands.

	Province							
Species	TEM	MAK	GC	CIP	MAL	ISA	WP	**TOTAL**
C. indicum		2	6	1	5	3	20	37
C. harveyi	33	1			1			35
C. salomonense					1		1	2
CANARIUM	33	3	6	1	7	3	21	**74**
T. catappa	2		1					3
T. kaernbachii		1					4	5
TERMINALIA	2	1	1	0	0	0	4	**8**
B. procera					3		2	5
B. edulis	2				2		2	6
B. novae-hiberniae	1	1			1		1	4
BARRINGTONIA	3	1	0	0	6	0	5	15
Total	38	5	7	1	13	3	30	**97**

4.2 Taxonomy

4.2.1 *Canarium*

All specimens collected belonged to *C. indicum* L., *C. harveyi* Seem. and *C. salomonense* Burtt. (Table 5, Appendix 1). In the vast majority of cases, species identification using stipules was not difficult.

[1] See Sect. 4.3 for species distribution in Solomon Islands.

Despite a constant lookout, *C. vulgare* Leenh. was not found. A possible *C. vulgare* in Iriri village, Kolombangara, WP (BSIP2155), referred to by Whitmore (1966), was not seen because the tree was chopped down in c.1986. The owner of the tree stated that it had been an 'import' from PNG. Several others had been planted but were never found.

Selection for fruit characteristics in *Canarium* by local people was evident all over Solomon Islands, especially in MAL, WP and TEM. Generally, fruits were selected for size, ease of opening, kernel taste, oil content, and, in some cases, the taste of the flesh (mesocarp).

C. indicum

All specimens of *C. indicum* were identified as var. *indicum* (hereafter abbreviated to CANIND). Whitmore (1966) reports two distinct forms of CANIND differing in leaflet size, but no such forms could be distinguished among the trees in this collection. Although the NIS of specimens from the WP were normally distinguishable from other provinces (see section 4.6: Fruit morphology) no good diagnostic characteristics could be found in their floral or vegetative morphology.

Identification of male and female trees was only possible by close inspection of flowers.

Stipules and leaflets were noticeably larger on juvenile trees.

C. salomonense

All *C. salomonense* specimens, plus many others which were observed but not collected, belonged to ssp. *salomonense* (CANSAL), with very little variation in vegetative, floral or fruit morphology. In contrast, Walker (1948) states that there are numerous CANSAL varieties, the nuts differing in appearance, ease of opening and kernel taste. This study found little perceptible variation in any of these characteristics, reflected by the low number of specimens collected.

The stipules of CANSAL proved to be a reliable taxonomic characteristic; distinctive from those of *C. harveyi* by being smaller (2–4 × 2–4 mm and 5–10 × 6–10 mm respectively), sub persistent, inserted further along the petiole (10–30 mm c.f. 2–10 mm for *C. harveyi*), and not on a flattened base (Plate 3).

Leaves of CANSAL were regularly found with three pairs of leaflets (c.f., Whitmore 1966), plus a single smaller terminal leaflet (see section 4.5.2). The underside of the leaflet blade was generally a lighter colour than the face.

C. harveyi

All but one of the *C. harveyi* specimens collected were identified as var. *nova-hebridiense* Leenh. on the basis of their fruit *shape*, although fruit size (undoubtedly due to cultivation) far exceeded that previously recorded for the variety (Leenhouts 1955, 1959).

Specimen STAR1, from East Makira, was identified as var. *sapidum* (Hems.) Leenh. because of its NIS shape (see Figure 9a; c.f. Figure 15k in Leenhouts 1955) and large tomentose flowers. The leaves of STAR1 carry up to six pairs of leaflets compared to the usual 2–4 for the species (Leenhouts 1959) and its kernels are edible. Interestingly, the vernacular for STAR1, 'Gatoga-A'Ngari', means a CANSAL × CANIND hybrid (the leaves from CANSAL, and the fruits from CANIND).

A.

B.

Plate 3: Stipules of: **A.** *Canarium salomonense* ssp. *salomonense* (× 0.9)
B. *C. harveyi* var. *nova-hebridiense* (× 0.6)

C. harveyi var. *nova-hebridiense* (CANHAR) was found to be polygamodioecious[2], not dioecious; no male-only flowered trees were found. Although many trees had predominantly male flowers, all were found to have some hermaphrodite[3] flowers which later produced fruits.

Observations over time on five planted CANHAR trees at Tenaru Field Experimental Station (TFES) near DCRS (Figure 4) showed that individual trees were either:

Gynomonoecious:

Female plus hermaphrodite flowers; the ratio of female to hermaphrodite flowers differing between trees and over time on the same tree; female and hermaphrodite flowers often on the same inflorescence; hermaphrodite flowers generally appearing first (Figure 4, trees C and E);

Andromonecious:

Male plus hermaphrodite flowers; the ratio of male to hermaphrodite flowers differing between trees and over time on the same tree; male and hermaphrodite flowers often on the same inflorescence; hermaphrodite flowers generally appearing first (Figure 4, trees A, B and D);

No tree was found with male and female flowers. No evidence was found in the field to indicate that hermaphrodite flowers (from either mostly-male or mostly female trees) self fertilised. Isolated single planted trees were found with fruit on them suggesting that hermaphrodite flowers cross fertilise. It is not known whether a tree changes type over time; possibly all trees are hermaphrodite at first before separating in to the two types. The sex of CANHAR flowers could be distinguished relatively easily in the field by the following characteristics:

Male	Ovary and stigma undeveloped/rudimental. Stamens 6; equal size.
Female	Well developed stigma and ovaries. Stamens under-developed, smaller than male, anthers thin, empty with no pollen (Plate 4a).
Hermaphrodite	Well developed stigma, ovaries, stamens, anthers with (yellow) pollen (Plate 4b).

A full description of the hitherto inadequately described *C. harveyi* var. *nova-hebridiense* Leenh. from Solomon Islands, based on the specimens collected in this survey, is given in Appendix 2.

4.2.2 *Terminalia*

Only *T. catappa* L. and *T. kaernabachii* Warb. were collected (Table 5, Appendix 1). *T. impediens* Coode was not found.

T. catappa

In most places, very little intra species variation was found in *T. catappa* (TERCAT).

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2 A population of plants with gynomonoecious (hermaphrodite and female flowers on the same plant/tree) and andromonoecious (hermaphrodite and male flowers on the same plant/tree) individuals/trees.

3 Male and female reproductive organs on the same flower.

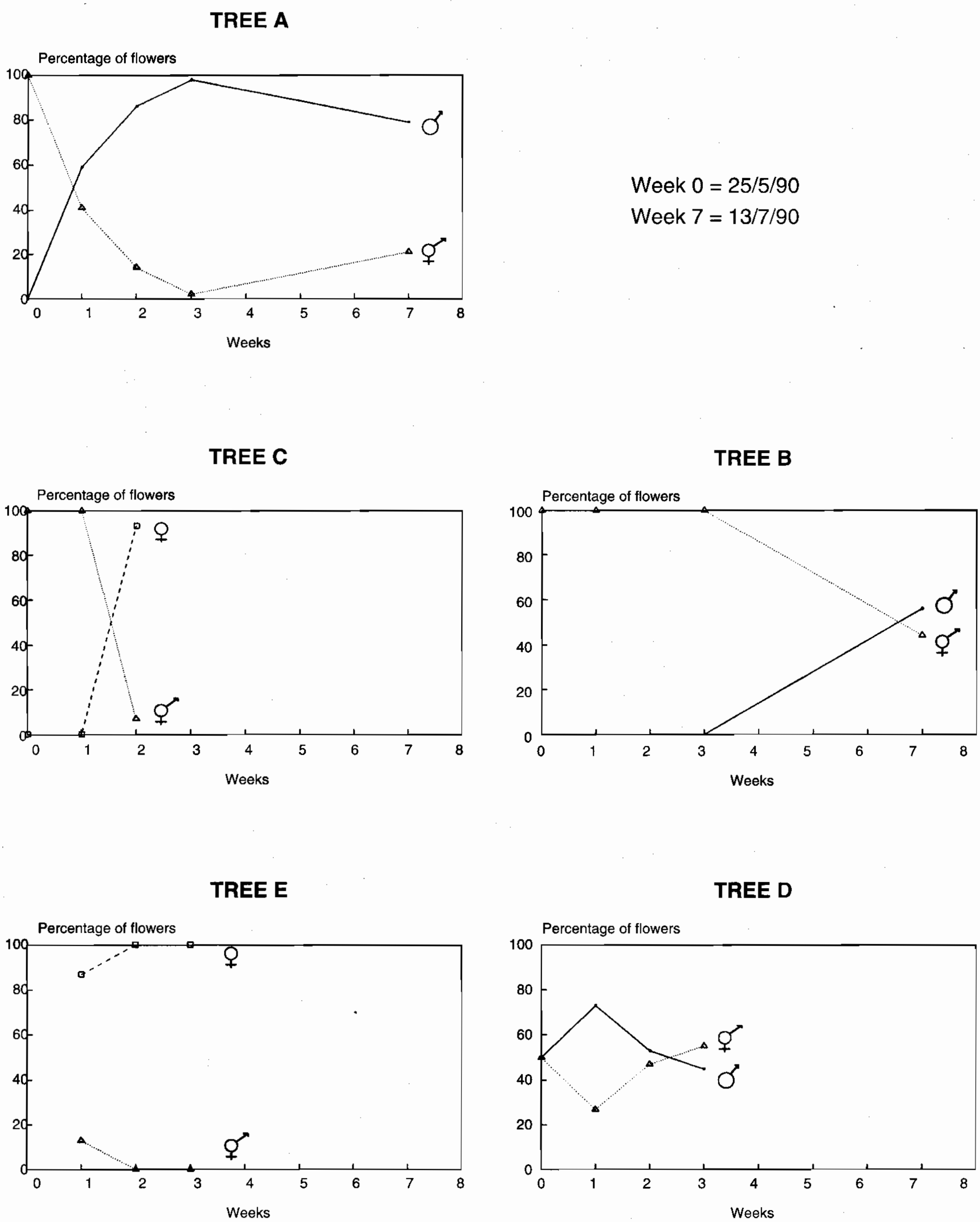


Figure 4: Floral biology of *Canarium harveyi* at Tenaru Field Experiment Station.

A.

B.

Plate 4: Flowers of *Canarium harveyi* var. *nova-hebridiense* (× 5).
A. Female **B.** Hermaphrodite
From tree planted at Tenaru Field Experiment Station, Guadalcanal.

On the Reef Islands of Temotu Province, local people divide the species into two groups, based on the colour of the petiole which is either light red or, more normally, light grey. However, this classification system is confounded by the deciduous habit of the tree which periodically produces a red colouration in the leaves and petioles of both groups prior to leaf fall. Each group is further subdivided into fruit forms based on the colour of the corky endocarp which is either white or (anthocyanin) red.

Selection in TEM and other provinces has produced some large fruited forms.

T. kaernbachii

No intra species variation was found in the introduced, and still comparatively rare, *T. kaernbachii* (TERKAE) in Solomon Islands.

4.2.3 *Barringtonia*

Considerable difficulty was experienced classifying a number of the *Barringtonia* specimens collected.

Payens (1967, page 209, in particular) used a number of morphological features (taken from herbaria material and collectors field notes) to distinguish edible *Barringtonia* spp.:

CHARACTER	*B. procera*	*B. edulis*	*B. novae-hiberniae*
Pedicel length	sessile	pedicelled	pedicelled
Calyx in bud	closed/open	closed	large apical pore
Petiole length	sub-sessile	short	long
Fruit shape	8-gonous	ovoid	broad obovoid
Fruit colour	purple	green	green or purple

Early in the collection it was evident that Payens' taxonomic criteria were inadequate for determining many of the specimens collected; partly because Payens based his criteria on difficult to interpret continuous measurements, and partly because of the cultivation of all three *Barringtonia* species in Solomon Islands. The main problems faced were:

1. Pedicel length:
   The distinction between pedicelled and sessile was difficult to judge in a number of specimens due to the tapering of the receptacle in to the pedicel.
2. Petiole length:
   Similar to above, the leaf base tapering in to the petiole.
3. Calyx in bud:
   The size (diameter) of the calyx apical pore ranged from less than 1 mm to over half the size of the bud, making it difficult to judge whether the calyx was closed or open. This character is also highly dependent on the time of observation—almost all specimens had a completely closed calyx very early in their development.

The difference in appearance between fresh *Barringtonia* fruits (and flowers) in the field, and dried material in herbaria, is also great and limits the usefulness (and validity?) of descriptions based largely on the latter.

Despite these difficulties, all specimens were eventually classified with a reasonable degree of confidence (Table 5, see also Appendix 1.2) as either *B. procera* (BARPRO), *B. novae-hiberniae* (BARNOV) or *B. edulis* (BAREDU) using mostly field taxonomic characteristics such as calyx in bud, leaf petiole and general tree form (Table 6). Identification using fruit characteristics alone was inaccurate and misleading, no doubt because of the selection and cultivation of fruits by local people.

Table 6. Taxonomic characteristics of ENTC *Barringtonia* collection in Solomon Islands.

Ref	Species	Province	Leaf (cm) Length Min	Leaf (cm) Length Max	Leaf (cm) Width Min	Leaf (cm) Width Max	Petiole Length (cm)	Fruit Shape	Fruit Colour	Pedicel Length (mm)	Calyx in bud?	Commments
GIZO4	EDU	WP						broad ovoid	green			purple endocarp
NGAM1	EDU	TEM	45	55	16	19	1.0–2.0	obovoid	green	Sessile	closed	
NGAM2	EDU	TEM	45	55	15	20	1.0	obovoid	purple	2–3	closed	easy to open
PALA2	EDU	MAL	44	48	15	17	6.5	obovoid	purple	pedicelled?	apical pore 3–5 mm diam.	
UGUL1	EDU	WP						cylindrical	purple			
WEIL2	EDU	MAL	38	58	15	23	3.5–5.0	ovoid	green	2–3	closed	purple endocarp
BARA4	NOV-HIB	WP						cylindrical	purple			
MALA1	NOV-HIB	TEM	20	30	7	8	3.0	ovoid-cylindrical	purple/grey	5	open	
MARA1	NOV-HIB	MAK	23	23	10	10	3.5	cylindrical	green	10	open	banana shaped
PALA4	NOV-HIB	MAL	25	35	10	15	7.0–10.0	cylindrical	green	3–5	open	
LALE2	PRO	WP						obovoid	green			
MUND5	PRO	WP					Sess	ovoid	green	Sessile	closed	easy to open
PALA1	PRO	MAL	45	50	15	17	1.0	obovoid	green	2–3	apical pore 3–6mm diam.	dwarf tree
PALA3	PRO	MAL	60	60	24	24	Sess	ovoid	green	2–3	apical pore	purple endocarp
WEIL1	PRO	MAL	48	48	18	18	1.0–2.0	broad-obovoid	grey/purple	Sessile	closed	

Evidence was also found of hybridisation among *Barringtonia* spp. A form known as 'Oliwea' on the Reef Islands (TEM) was reported to be a BARNOV × BARPRO sterile hybrid.

B. procera

Identification of BARPRO in the field was relatively easy. All trees had densely clustered, sessile, glossy, crinkled leaves and long thick fecund inflorescence.

Three cultivars were distinguishable based on fruit colouration (Table 7). A dwarf tree cultivar was collected only once (because of its unremarkable fruits), but was observed in a number of places.

B. novae-hiberniae

BARNOV is easily distinguishable from BARPRO in the field by its cupuliform calyx, on the bud (Plate 6b) and fruit (Plate 5b), and its long-petioled leaves (c.f., Plate 5a (i) with 5a (iv)).

Three cultivars were distinguishable based on fruit colour (Table 7), and, in the case of one striking specimen (MARA1), fruit length and shape (Plate 5b).

B. edulis

BAREDU is best distinguished from BARNOV in the field by its closed (or near closed) calyx in bud which ruptures to form 2–4 pseudo lobes with torn-fimbriate margins. However, differences between these two species are not always great. Both species have considerable intra-species variation and inter-species overlap in vegetative, floral and fruit characteristics.

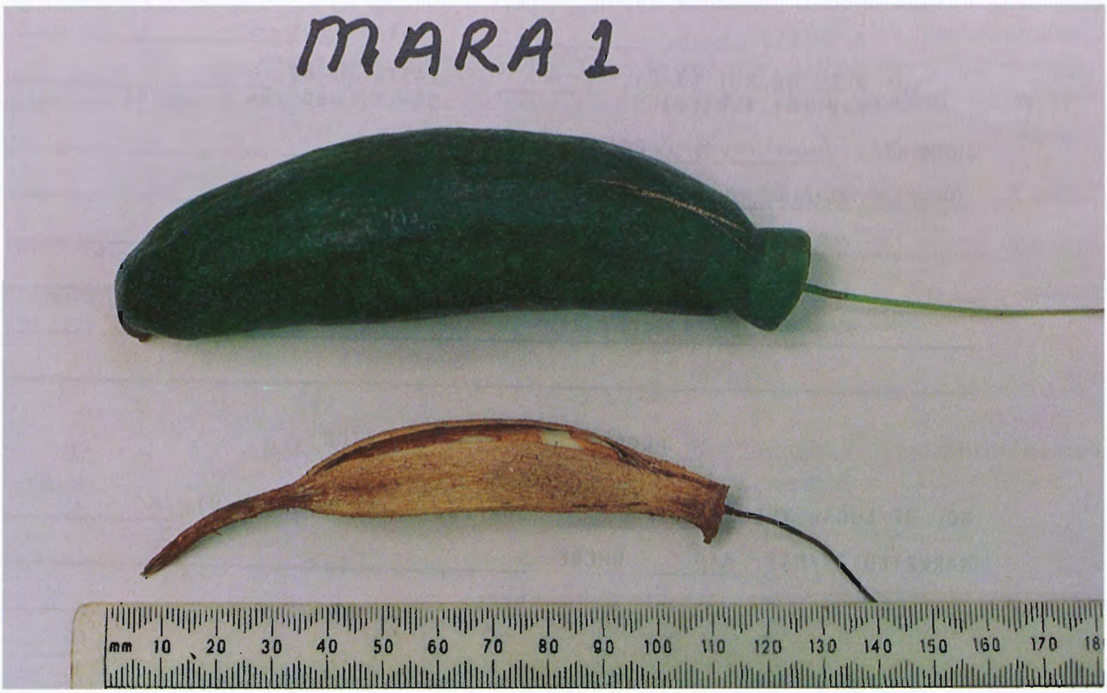
Purple and green fruited cultivars of BAREDU were found (Table 7).

There are, *without doubt*, many more cultivars of edible *Barringtonia* spp. in Solomon Islands.

Table 7. *Barringtonia cultivars in ENTC variety collection.*

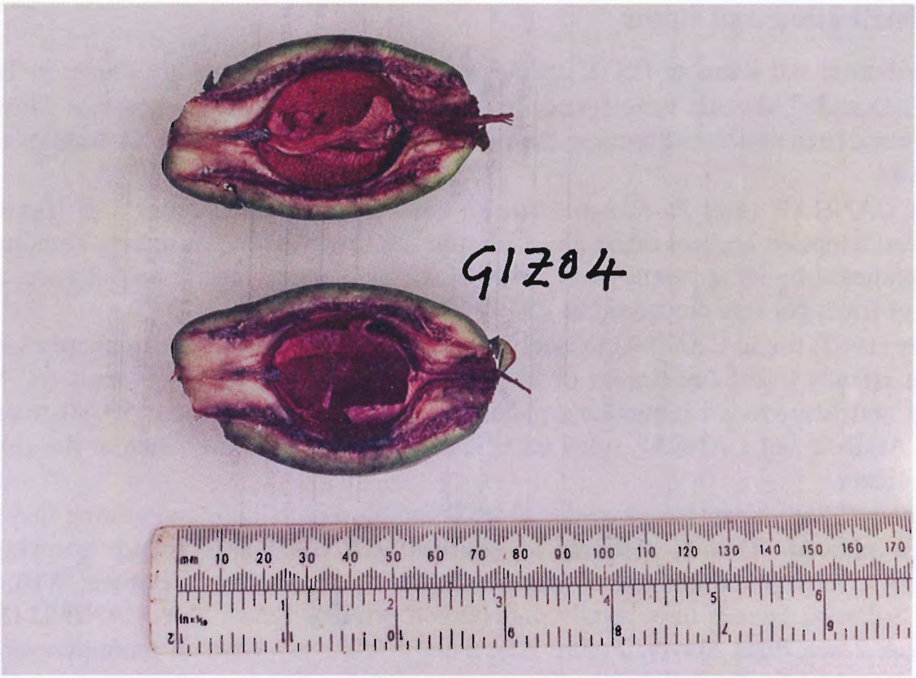
Species	*Cultivar*	*Specimen Refs*	*See Plate*
edulis	*1. purple fruit*	*PALA2/UGUL1/NGAM2*	*5a(ii)*
	2. green fruit + purple endocarp	*WEIL2/GIZO4/NGAM1*	*6a*
novae-hiberniae	*1. purple fruit*	*BARA4/MALA1*	*6b*
	2. green fruit	*PALA4*	*5a(iv)*
	3. green fruit + long fruit	*MARA1*	*5b*
procera	*1. purple/grey fruit*	*WEIL1*	*2b*
	2. green fruit	*LALE2/MUND5*	
	3. green fruit + purple endocarp + large leaf	*PALA3*	*5a(iii)*
	4. green fruit + dwarf tree	*PALA1*	*5a(i)*

A.

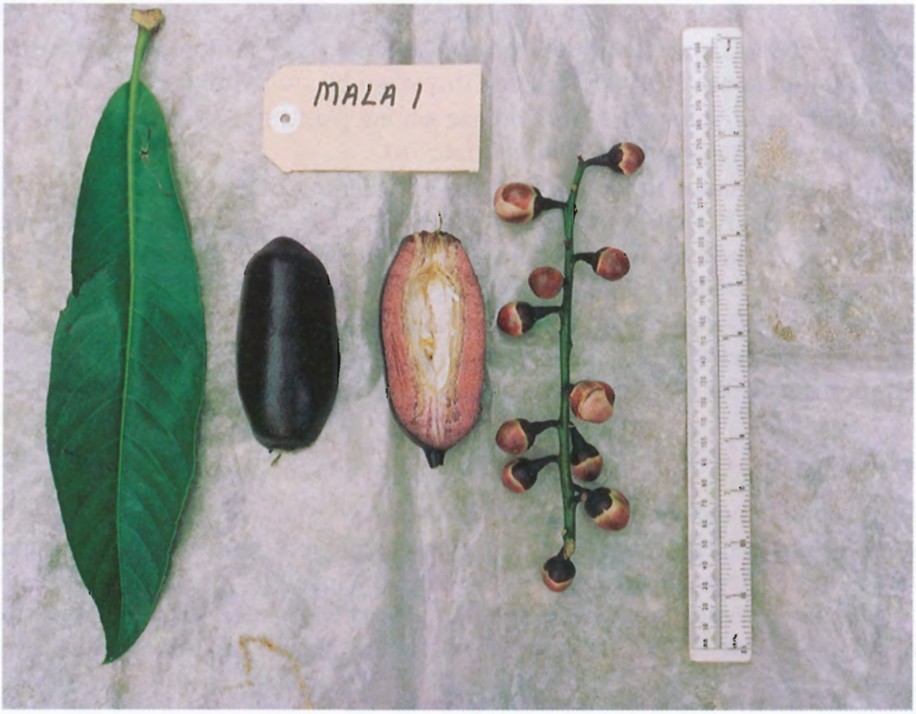


B.

Plate 5: **A.** i) *Barringtonia procera* (PALA1) (× 0.15); ii) *B. edulis* (PALA2), iii) *B. procera* (PALA3); iv) *B. novae-hiberniae* (PALA4).
B. *B. novae-hiberniae* (× 0.66).



A.



B.

Plate 6: **A.** *Barringtonia procera (× 0.52)*
B. *B. novae-hiberniae (× 0.23)*

4.3 Distribution and status

The distribution and status of ENTC species within Solomon Islands are shown in Table 8.

CANIND and CANSAL were found throughout Solomon Islands except in TEM where they have not been cultivated because their fruits are regarded as inferior to those of the local CANHAR[4].

Single CANHAR (var. *Nova-hebridiense*) were found planted outside of Temotu, but widespread adoption has not taken place (despite its fruit size) because non-Temotu people are disappointed by its apparent slow growth, susceptibility to insects and disease, and low number of fruits per tree compared to CANIND.

Walker (1962) found CANIND to rarely account for more than 5% of total crop volume in Solomon Islands forest (maximum of 24% in Heho, Malaita). In some areas (N. Malaita, Rendova and Marovo, in particular), plantings of over 2 ha (at about 50–80 trees/ha) of mixed CANIND and CANSAL (plus other species) were observed; often at the site of old inland villages.

Whitmore (1966) never found wild CANIND in Solomon Islands, suggesting that all trees had been planted. This is difficult to confirm. CANIND was found 'growing wild' (according to locals) in a number of sparsely populated places (e.g., Tetapare, WP), but few areas in Solomon Islands have totally undisturbed primary forest. Two CANIND (SALA 1 and SALA 2 see Plate 8biv/v, Figure 8d), from a relatively isolated mountainous area of Guadalcanal, had fruits well below the average size for the species, suggesting that they perhaps represent uncultivated wild types. However, altitude is also likely to affect fruit size.

In contrast, CANSAL is generally considered to grow wild in more remote areas as their smaller fruits are more easily swallowed and dispersed by frugivorous birds.

Typically, villages in Solomon Islands are set among planted coconuts with CANIND plus CANSAL occupying the surrounding hills (Plate 7a).

TERCAT is very common in all coastal areas of Solomon Islands, but is rare inland. Only single planted TERKAE were found, mostly in garden (or old garden) sites. However, the nuts are highly esteemed by local people and the trees adoption, eastwards out of PNG (where it originates [Coode 1978]), is increasing, but has yet to reach TEM.

All three species of *Barringtonia* were found in all provinces, usually in or around villages where they were frequently cultivated by seed, and, in some areas, cutting. BARNOV was also found growing 'wild' in inland areas, usually secondary forest.

4.4 Vernaculars

A list of vernaculars (local names) for the species studied is given in Table 9. There being 99 languages in Solomon Islands, the list is far from complete. Where possible the names have been recorded in the language area, not — as so often happens — from migrants in Honiara; a practice which experience suggests is fraught with errors. Spelling is inevitably variable in what are predominantly spoken languages, but often this makes very little difference to phonetics.

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4 The Solomon Islands forest inventory found CANSAL in Temotu province (Solomon Islands Government, 1992–1993).

A.

Plate 7: **A.** Ugele village, Rendova, Western Province. Note: *Canarium indicum* and *C. salomonense* immediately behind coconuts. 1988.
B. *C. harveyi* var. *nova-hebridiense* (LONE1), Neo Is, Santa Cruz. Oct 1988. Note: loss of leaves.

B.

Table 8. Distribution and status of ENTC within Solomon Islands.

Species	Province						
	TEM	MAK	GC	CIP	MAL	ISA	WP
CANIND		Co/W+Cu	Co/Cu+W	Co/Cu+W	Co/Cu+W	Co/Cu+W	Co/Cu+W
CANHAR[2]	Co/Cu	U/Cu	R	R	R	R	R
CANSAL		Co/W+Cu?	Co/W	Co/W	Co/W+Cu	Co/W	Co/W+Cu?
TERCAT	Co/Cu	Co	Co	Co	Co	Co	Co
TERKAE		U	R	?	R	R	U
BARPRO	Co/Cu	Co/Cu	Co/Cu	Co/Cu	Co/Cu	Co/Cu	Co/Cu
BAREDU	Co/Cu	Co/Cu	Co/Cu	Co/Cu	Co/Cu	Co/Cu	Co/Cu
BARNOV	Co/Cu+W	Co/W+Cu	Co/W+Cu	?	Co/W+Cu	Co/W	Co/W+Cu

Notes:

1.

Code	Meaning	Notes
Co	Common	Found throughout province
U	Uncommon	Found sparodically, often only in certain areas
R	Rare	Individual trees only, usually imports
Cu	Cultivated	Selection of superior vars. by local people over time, usually best vars. are located near village sites
W	Wild	Trees propagated without selection by local people, usually in higher more remote forest
W+Cu		Primarily wild, with some cultivation, viceversa for Cu+W
?	Unclear	Insufficent information

Often a single name is given for all species within a genus, but specific names are shown when they are clear and unambiguous.

The list does little justice to the precision of some languages in describing varieties. For example in Aiyawo (the language spoken in the Reef Islands of TEM) informants were able to name 14 fruit forms of CANHAR according to fruit shape, size and colour.

The borrowing of names, and the relationships between provinces is striking and undoubtedly reflects past inter-tribal links through trade and warfare.

It is worth noting here that many of the specimens in Honiara herbarium (BSIP) labelled with the Kwar'ae vernacular 'Mala'adoa' have been (incorrectly) determined as CANSAL[5]. While 'Mala'adoa' (= 'like adoa') evidently refers to a number of species (CANHAR and *C. vitiense* in particular) and other genera within Burseraceae (*Haplolobus* and *Garuga*), the vernacular 'Adoa' is **specific** to CANSAL. Local people, and especially Kwar'ae plant namers, never have any difficulty distinguishing the fruits of CANSAL from other trees because of their importance as a food crop.

Most vernaculars for edible *Barringtonia* in Solomon Islands describe fruit characteristics only. BARPRO (domestic/village cut nut) is normally differentiated from BARNOV (wild/bush cut nut).

BAREDU is mostly grouped with BARNOV (possible because of its petioled leaves) but is sometimes assigned a specific name.

BAREDU in South Malaita is referred to as 'Aitapi roma' (cut nut-fish poison) reflecting its dual use as a food and fish poison extracted from the bark (similar to the seed of *B. asiatica*).

[5] A full list of plant determinations made by the author at various herbaria around the world is given in Appendix 3.

Table 9. Vernacular names of edible nut tree crops in Solomon Islands.

			Species							
Prov	Island	Language	Canind	Canhar[1]	Cansal	Baredu	Barproc	Barnov	Tercat	Terkae
ALL	**Solomon Islands**	**Pidgin**	**ngali**	**Santa Cruz ngali**	**Wild/Bush ngali**	**Cutnut**	**Cutnut**	**Wild/Bush Cutnut**	**Alite**	**Bush Alite**
					ngali					
CIP	Florida	Gela	Nali		Gadoga		Mega	Mega	Tahile	
GC	Guadalcanal	Birao	ngali							
GC	Guadalcanal	Tadhimboko	Sela							
ISA	Isabel	Maringe	Sitha		Khajoga		Fala	Fala mata	Naklise	
ISA	Isabel	Mbughotu	ngali		Gajoga		Mega		Talihe	Talihe
ISA	N.Isabel	Kia	Kabala		Finua		Nofe		Titilehe	
MAK	E.Makira	Kahau	A'Ngari		Gatoga		Hara (Mora)		Arete/Oko	
MAK	Santa Ana		Angari		Gatoga		Fara		Arite	
MAK	W.Makira	Arosi	Ngari		Adoa		Aitabi	Aitabi	Arite	Arite aba
MAL	N.Malaita	To'oabaita	ngali		Afisu		Kenu		Alita	Alita fasia
MAL	N.Maliata	Kwar'ae	ngali	see note 2	Andoa		Fala/Hala	Fala kwasi	Alita	Alita fasia
MAL	S.Malaita	Are Are	ngali		Aiwasi	Aitapi roma	Aitapi			
MAL	S.Malaita	Sa'a	ngali		Arau				Alite	
TEM	Nendo	Graciosa Bay		Nolepo			Nuva		Namba	
TEM	Reef Is.	Ayiwo		Nyinga			Nuwa	Nuwa (ola)	Nyingaa	
WP	Choiseul	Mbambatana	Kaku		Sanqa		Vele	Vele Pipizi	Talike	
WP	E.New Georgia	Marovo	Ngoete		Maria		Tinge		Talise/Piru	Talise Manavasa
WP	Ranongga	Lungga	Ngari		Eni		Rupe		Talise	Talise Tangasa
WP	Rendova	Hanasu	Veo		Yitofo					Rhise
WP	Shortlands		Kaii		Kamale		Sioko		Saori	Saoringale
WP	Simbo	Kusage	Ngari		Nemba		Kinu (Huala)		Tatalise	
WP	Vella	Mbilua	Mbama		Pati		Rupe		Talivale	Maku Talivale
WP	W.New Georgia	Roviana	Okete		Tovinia		Tinge		Tatalise	Tatalise hogolo

Source: Authors field notes; and Henderson and Hancock (1988).
Notes:
1. var. *nova-hebridiense*.
2. vars. of CANHAR other than var. *nova-hebridiense* are known as 'Mala'andoa'.

4.5 Tree data

4.5.1 Form

Canarium

The average height of CANIND and CANSAL trees in the ENTC variety collection was 20 m, some 7 m taller than CANHAR (Table 10). CANIND and CANSAL commonly have flying buttresses and long straight boles up to 15 m tall. CANIND, in particular, has massive spreading limbs. In contrast, CANHAR rarely produces substantial buttresses and is generally less massively limbed than CANIND.

The three species are easily distinguishable by their crown alone; the high number of leaflets per leaf of CANIND and their individual size (see below), gives its crown a fuller and denser appearance to that of CANSAL and CANHAR. The latter species periodically appears even less dense because of leaf fall during fruit maturity (Plate 7b).

As the age of specimen trees was only estimated by their respective owners, the figures can not be verified. However, in view of the importance attached to ngali nut trees by local people (for example, in many cases the trees were planted to commemorate the death of a relative), the figures collected, at least for trees less than 50 years old, can be treated with some confidence. Figure 5 shows that both tree height and diameter at breast height (dbh) could be associated with estimated age for CANIND and CANHAR. Chaplin (1988) found the dominant height of 5-year-old CANIND (planted at 5 × 3 m) to be 14 m.

Canarium trees are periodically damaged by cyclones and are sometimes pruned by local people in Solomon Islands. This affects the crown width of trees, so these figures again should be treated with caution. Where undamaged mature unpruned trees were observed, it was clear that all three species were capable of producing wide canopies in excess of 15 m diameter depending on spacing, site and soils.

A number of stunted *Canarium* trees were observed in waterlogged sites; all three species evidently preferring well-drained soils.

Local people maintain that CANSAL are shade tolerant compared to CANIND, which they consider to be more domesticated, and so require greater site clearance and light during establishment.

A large minority of CANIND and CANSAL trees in Solomon Islands have been damaged by cyclones. In some areas, such as S. Malaita and E. Makira, local people reported that more than half the trees had been damaged recently. They added that this was probably because most of the existing trees were very old (relatively few trees have been planted in the past 50 years). Younger trees, on the other hand, appear to be able to withstand strong winds better; their strong tap roots apparently resisting uprooting. As a result, younger trees are frequently seen with their canopy snapped clean off at the top of the bole. In time, side shoots appear leading to a bificated trunk, again a common sight.

Because of their size and long straight bole, *Canarium* are frequently planted in association with 'living ladder' shade-tolerant companion trees (with low lateral branches such as *Terminalia* spp.) to facilitate easy climbing.

Barringtonia

All three species of *Barringtonia* can grow quite large if allowed to, which they seldom are because of their usual proximity to village houses or because of shading by neighbouring trees when found in the bush. BARNOV, known as the wild cutnut in Solomon Islands, is said to be more shade-tolerant than the domesticated village-based BARPRO and BAREDU.

Terminalia

Both species have the characteristic *Terminalia* pagoda-like lateral branching and deciduous leaf fall, 2 to 3 times per year in Solomon Islands.

Mature TERCAT are stout, broad trees with a short (often twisted) easily climbed bole and large open canopy.

TERKAE are more slender and thinner branched trees. In Solomon Islands, the canopy is rarely seen with a full set of leaves.

Table 10. Tree height, dbh and canopy width of ENTC variety collection[1].

	Height (m)		DBH (cm)		Canopy width (m)	
Species	max.	**av.**	max.	**av.**	max.	**av.**
CANIND	30	**21**	159	**91**	17	**11**
CANHAR	22	**14**	99	**63**	18	**11**
CANSAL	22	**20**	64	**55**	12	**7**
TERCAT	17	**14**	105	**77**	12	**12**
TERKAE	10	**10**	40	**34**	10	**8**
BARPRO	10	**8**	32	**22**	7	**6**
BAREDU	10	**8**	45	**26**	9	**6**
BARNOV	10	**8**	95	**39**	12	**6**

Notes:
All non-diseased trees over 10 years old.

4.5.2 Leaves

The following leaf descriptions are taken from *fresh* material.

Canarium

C. indicum var. *indicum*

Imparipinnate; 6–8 pairs of leaflets, plus one terminal. Petiole about 8 cm, seldom carrying the stipule; petiolules 2–4 cm. Leaflets oblong-elliptic (sometimes ovate or obovate) 16–35 × 5–13 cm (leaflets of juvenile often much larger), coriaceous; margin entire (often sinuate-undulate in young and older leaves); base obtuse (often with unequal sides); apex (sub) acuminate (acumen about 2 cm, recurved); nerves 8–12 pairs.

C. salomonense ssp. *salomonense*

Imparipinnate; 2–3 pairs of leaflets, plus one terminal. Petiole 6–8 cm, bearing the stipules 1–3 cm from base; petiolules about 2 cm. Leaflets ovate-elliptic 13–15 × 7–8 cm; margin entire; base sub-cordate; apex blunt acuminate; nerves 8–10 pairs.

Figure 5.1: Age vs Tree height
Canarium indicum

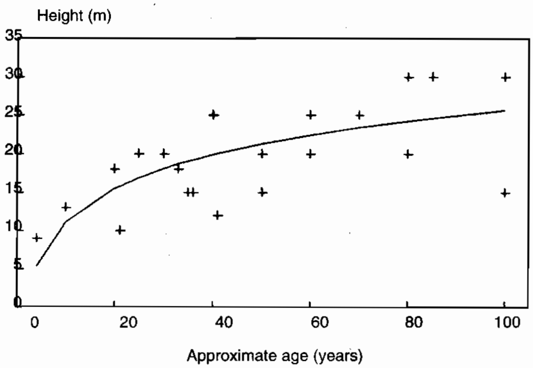


Figure 5.2: Age vs Tree height
Canarium harveyi var. *nova-hebridiense*

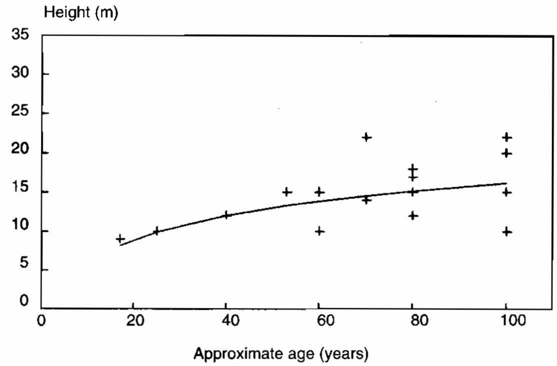


Figure 5.3: Age vs dbh
Canarium indicum

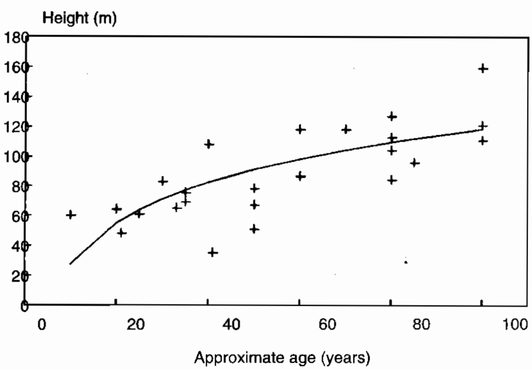


Figure 5.4: Age vs dbh
Canarium har veyi var. *nova-hebridiense*

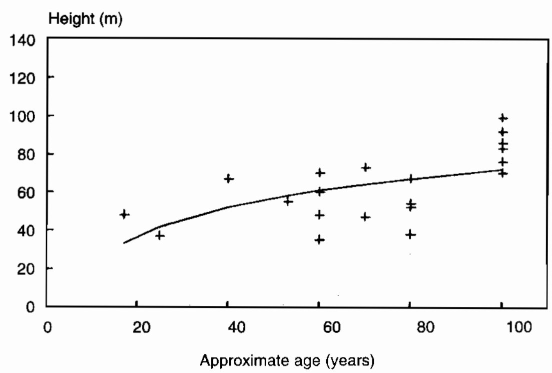


Figure 5: Tree age (owners estimate) vs height/dbh in ENTC variety collection (all non-diseased trees).

C. harveyi var. *nova-hebridiense*

Imparipinate; 3 (2–4) pairs of leaflets (base pair often reduced), plus one terminal. Petiole 6–10 cm flattened at base, carrying stipules 0.2–1 cm from base. If stipules missing (common) twin raised scars; petiolules 1–3 cm. Leaflets ovate-lanceolate (sometimes elliptic) 10–30 × 5–15 cm, subcaducous at fruit maturity (Plate 7b); margin entire-undulate; base sub-cordate (sometimes with unequal sides); apex (sub) acuminate (acumen 1.5–2 cm recurved); nerves 8–13 pairs.

Terminalia

T. catappa

Deciduous. Terminal bunches. Petiole 0.5–1.0 cm. Leaves obovate 15–30 × 10–18 cm, light green turning red before falling; margin entire; base subcordate; apex obtuse; nerves 7–10 pairs.

T. kaernbachii

Deciduous. Terminal bunches. Petiole 1–2 cm. Leaves obovate 15–30 × 10–18 cm, thick leathery, indumentum on underside, dark green turning blotchy red then red before falling; margin entire; base cuneate; apex obtuse-cuspidate.

Barringtonia

B. procera

Terminal bunches. Petiole 0–1(2?) cm, flattened at base, 12–20 mm diam.; Leaves obovate-oblanceolate (oblong) 45–50(60) × 15–18(24) cm, coriaceous, dark green; margin entire, crenulate towards apex; base attenuate; apex acute-acuminate; nerves 10–15 pairs, not reaching the margin, prominent especially on underside; lamina crinkled, undulate.

B. edulis

Terminal bunches of 10–15 leaves. Petiole 3.5–6.5 cm, 8–10 mm diameter; Leaves obovate-oblanceolate (elliptic) 38–58 × 15–23 cm, coriaceous; margin entire; base attenuate; apex cupsidate; nerves 15–18 pairs; lamina flat.

B. novae-hiberniae

Scattered. Petiole 3–10 cm; Leaves elliptic-obovate — oblanceolate 20–35 × 7–15 cm; margin entire; base cuneate; apex acuminate; nerves 10–13 pairs, not reaching the margin; lamina flat.

4.5.3 Fruiting period/frequency

Canarium

CANIND and CANSAL generally flower shortly after fruit fall towards the end of the year at the beginning of the wet season. Fruits take 5–8 months to mature, indicated by their skins turning green to black.

According to their owners, the fruits on CANSAL trees mature from June onwards (Figure 6), about 1–2 months before the majority of CANIND.

CANIND trees in the Western province fruit a little earlier than those in provinces further east.

Fruit production of CANIND and CANSAL reaches its peak during August and September. Consequently, in the 1990 commercial purchase of nuts from smallholders supply peaked during October (Evans 1991c).

The majority of CANHAR trees in Temotu province fruit later in the year, from October onwards. Depending on seasonal fluctuations in weather (especially the length and intensity of the wet and dry periods) up to a quarter of the trees either fruit earlier in the year during a 'mini-season' or produce fruit twice a year. Flowering takes place after fruit fall at the end of the year.

BUAL1, a CANIND from Isabel province, was reported and observed to regularly fruit from March onwards, 3–4 months before neighbouring trees. The tree had been top lopped about 3 years before which may have affected its phenology. A number of owners reported that ngali nut trees respond to pruning by vigorous regrowth and unseasonable flowering. Similarly, Chaplin (1985) observed the same vigorous regrowth on coppiced CANIND trees.

Such a response to pruning may have important economic and silvicultural benefits for future plantations by minimising the recovery period of cyclone damaged trees and lengthening the period of supply.

Barringtonia

All 3 species of *Barringtonia* in the ENTC variety collection were recorded as fruiting 2 to 3 times per year; the quantity and time of fruiting depending on the condition of the tree and seasonal fluctuations in weather, but with no apparent inter-species pattern.

Terminalia

TERCAT fruits sporadically throughout the year in Solomon Islands. TERKAE fruits between June and September.

4.6 Fruit morphology

4.6.1 *Canarium*

The size, shape and the weight of fruits, nuts-in-shell (NIS) and kernels-in-testa (KIT) of the three *Canarium* species collected differed considerably (Table 11, Figure 7, Plate 8a).

The fruits, NIS and KIT of CANHAR were larger, heavier and had a higher K:N ratio than those of CANIND and CANSAL.

Although the NIS of CANSAL was smaller and lighter than CANIND, its average K:N ratio was higher.

The average KIT weight of CANHAR was almost double that of CANIND and 4 times that of CANSAL.

On a fresh weight basis (an altogether much more unreliable statistic because of variations in moisture content) KIT weight was on average 9, 10 and 14% of fruit weight for CANIND, CANSAL and CANHAR respectively (Appendix 4).

The fruits from several trees were collected in 1988 and 1989 in order to compare NIS characteristics over time. Differences, particularly in NIS cross section shape (but not in size), were minimal. A statistical analysis was not possible, however, because of the need to preserve seed for planting.

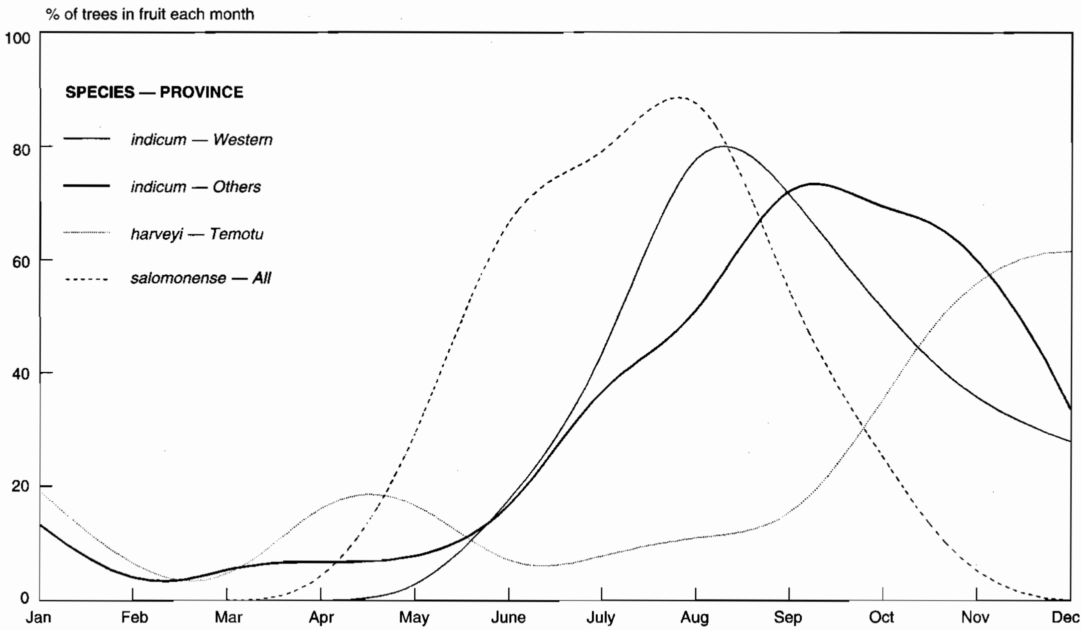


Figure 6: Fruiting period of *Canarium* spp. in Solomon Islands. Data taken from ENTC variety collection; owners estimates.

C. indicum

Intra-specific variation was greatest in CANIND. NIS length (l) ranged from 28 to 62 mm, width (w) 20–35 mm, circumference(c) 65–110 mm and weight from 8–20 g (Table 11). The cross-section shape of NIS ranged from almost round to 6-sided (Figure 8, Plate 8b). The sterile cells of some specimens were almost completely reduced, while in others they were the same size as that of the fertile seed cell. Shell thickness ranged from 2–5 mm (Table 12, see also below).

The NIS of CANIND from the Western province in general, and those from Marovo (E. New Georgia) in particular, were larger and heavier, and had a higher K:N ratio than those from other provinces (Table 11; compare column 1 (Other Provinces) of Plate 8b with column 2 [Western province]).

Two of the specimens collected from the mountains of Guadalcanal (alt. about600 m), SALA1 and SALA2 (Figure 8d, Plate 8b(iv/v)), were very small (28 × 22 × 70 mm [l × w × c] and 41 × 21 × 65 mm respectively) and may represent uncultivated forms, but supposed 'wild' CANIND forms from western PNG are allegedly much larger (Leenhouts pers. comm.).

The fruit characteristics of two CANIND specimens were of special interest:

NUAT1 has a mesocarp that cracks and falls away from the NIS after fruit fall (Plate 9a). Normally the mesocarp sticks to the shell before rotting away.

SANG1 has a very thin shell (1.9 mm c.f. av. of 3.7 mm) resulting in the NIS being very easy to open (even with conventional hand-held jaw nut crackers) and a high K:N ratio (26%) (Figure 8b, Plate 8b xiii). Unlike all other *Canarium* specimens collected, the fresh NIS float in water.

C. harveyi

Generally, intra-specific variation in the fruit morphology of CANHAR was less than that of CANIND. NIS length for CANHAR ranged from 45–80 mm, width 25–40 mm, circumference 65–110 mm and weight from 12–21 g (Table 11).

The cross-sectional shape of most NIS was 2 or 3-sided with rounded edges and a total (or near total) reduction in the sterile cells (Figure 9). Conspicuous longitudinal ribbing was evident on a number of specimens (Plate 9b). Shell thickness ranged from 3–4 mm (Table 12).

Two specimens were of special interest:

BAUN1 informants reported that the majority of fruits from this tree (the only one of its kind on the Reef Is.) contained 3 fertile seeds (Figure 9b, Plate 10a).

NOPA1 all NIS were found to have a single seed made up of 2 cotyledons each with 5 lobes, compared to the normal 3-lobed cotyledons (Plate 10b).

C. salomonense

Very little variation in fruit morphology was observed in CANSAL (NIS: 30–37 × 14–19 × 50–58 mm) (Table 11). The cross section of all CANSAL observed was ellipsoid, the sterile cells always strongly reduced (Figure 7e). Shell thickness averaged 3 mm (Table 12).

Table 11. Size and weight of *Canarium* fruits in ENTC collection.[1]

Species =	CANIND				CANHAR		CANSAL		*Canarium*	
Province =	WP	Others	All		All		All		All	
	Av.	Av.	Av.	Max.	Av.	Max.	Av.	Max.	Av.	Max.
Size analysis (mm)										
Fruit										
Length	60	53	56	75	66	90	n.a.[2]	n.a.	62	90
Width	36	35	36	45	40	52	n.a.	n.a.	38	52
Circumference	123	109	113	150	112	140	n.a.	n.a.	112	150
Nut-In-Shell										
Length	49	44	47	62	61	80	35	37	52	80
Width	28	26	27	35	33	40	19	19	29	40
Circumference	84	79	82	110	84	110	54	58	82	110
Kernel-In-Testa										
Length	37	34	35	45	42	55	25	25	38	55
Width	20	16	18	23	25	30	13	14	21	30
Circumference	50	43	46	60	60	72	37.5	40	52	72
Weight analysis (g)										
Fresh fruit	34.8	31.2	33.2	40.0	41.2	55.0	12.5	16.0	38.3	55.0
NIS[3]	13.6	10.6	12.4	20.0	15.4	20.9	4.8	5.5	13.3	20.9
Dry KIT[4]	2.3	1.5	2.0	4.0	3.9	5.7	0.9	0.9	2.7	5.7
Testa	n.a.	n.a.	0.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
K:N ratio (%)	18	14	16	27	24	32	18.5	21	20	32

Notes:
1. Figures are an average of more than 20 trees × minimum of 5 fruits for CANIND plus CANHAR, and 5 trees × 5 fruits for CANSAL.
2. not available
3. < 5.0% m.c.
4. < 1.0% m.c.

Table 12. Shell thickness of *Canarium* in Solomon Islands.

Species	Province	Shell thickness (mm)[1] Min.	Max.	Av.
C. indicum	WP	1.9	4.9	3.4
	Others	4.1	4.6	4.3
	All	1.9	4.9	3.7
C. harveyi[2]	All	2.8	4.0	3.4
C. salomonense	All	2.5	3.6	3.4
All	All	1.9	4.9	3.5

Notes:
1. Measured at centre of lid.
2. Var. nova-hebridiense.

A.

B.

Column 2

Column 1

Plate 8: *Canarium spp. nut-in-shell shapes.*

A. *i) C. harveyi var. nova-hebridiense (MALA2),*

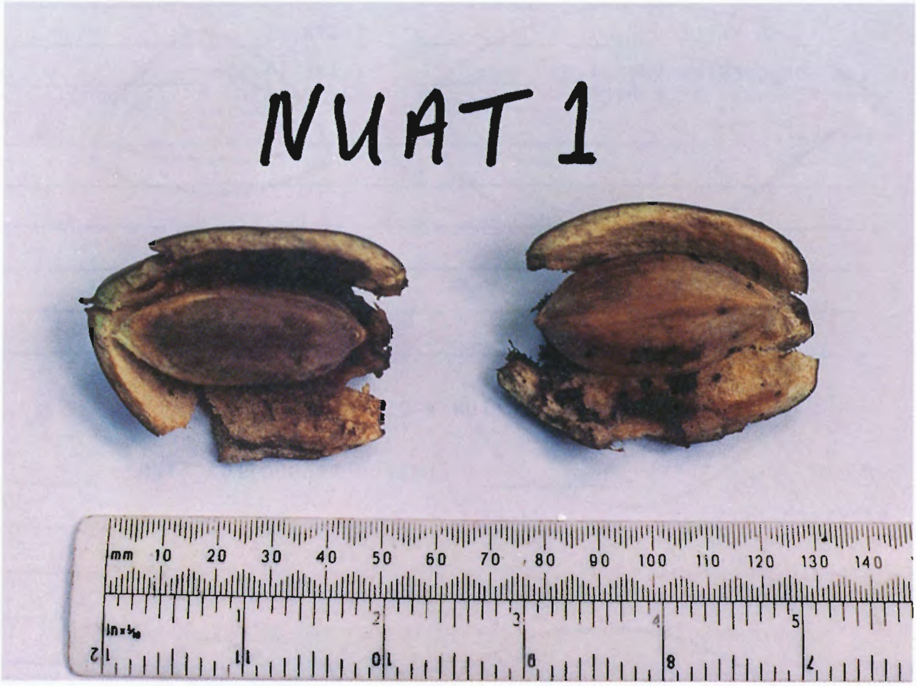
ii) C. indicum var. indicum (PENJ1), *(x 0.6)*

iii) C. salomonense ssp. salomonense (LOKU2)

B. *C. indicum var. indicum*

Column 1: (i–vii pairs of NIS plus cross section): Western Province

Column 2: (viii–xiv pairs of NIS plus cross section): Other Provinces *(x 0.4)*



A.

B.

Plate 9: **A.** *Canarium indicum* var. *indicum* (× 0.67)
B. *C. harveyi* var. *nova-hebridiense* (× 0.35)

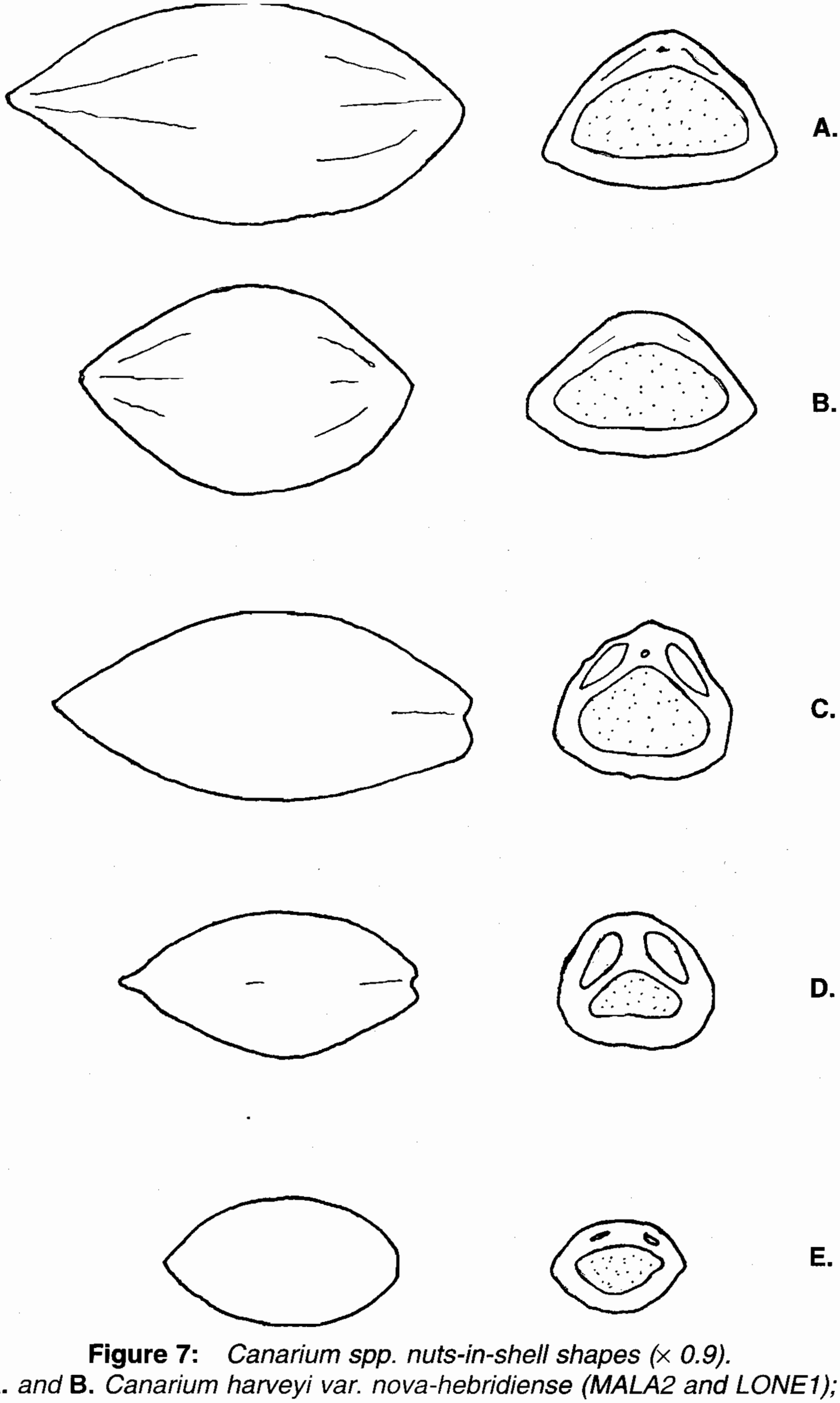


Figure 7: *Canarium spp. nuts-in-shell shapes (× 0.9).*
A. *and* **B.** *Canarium harveyi var. nova-hebridiense (MALA2 and LONE1);*
C. *and* **D.** *C. indicum var. indicum (SIMB1 and FOON2);*
E. *C. salomonense ssp. salomonense (LOKU2).*

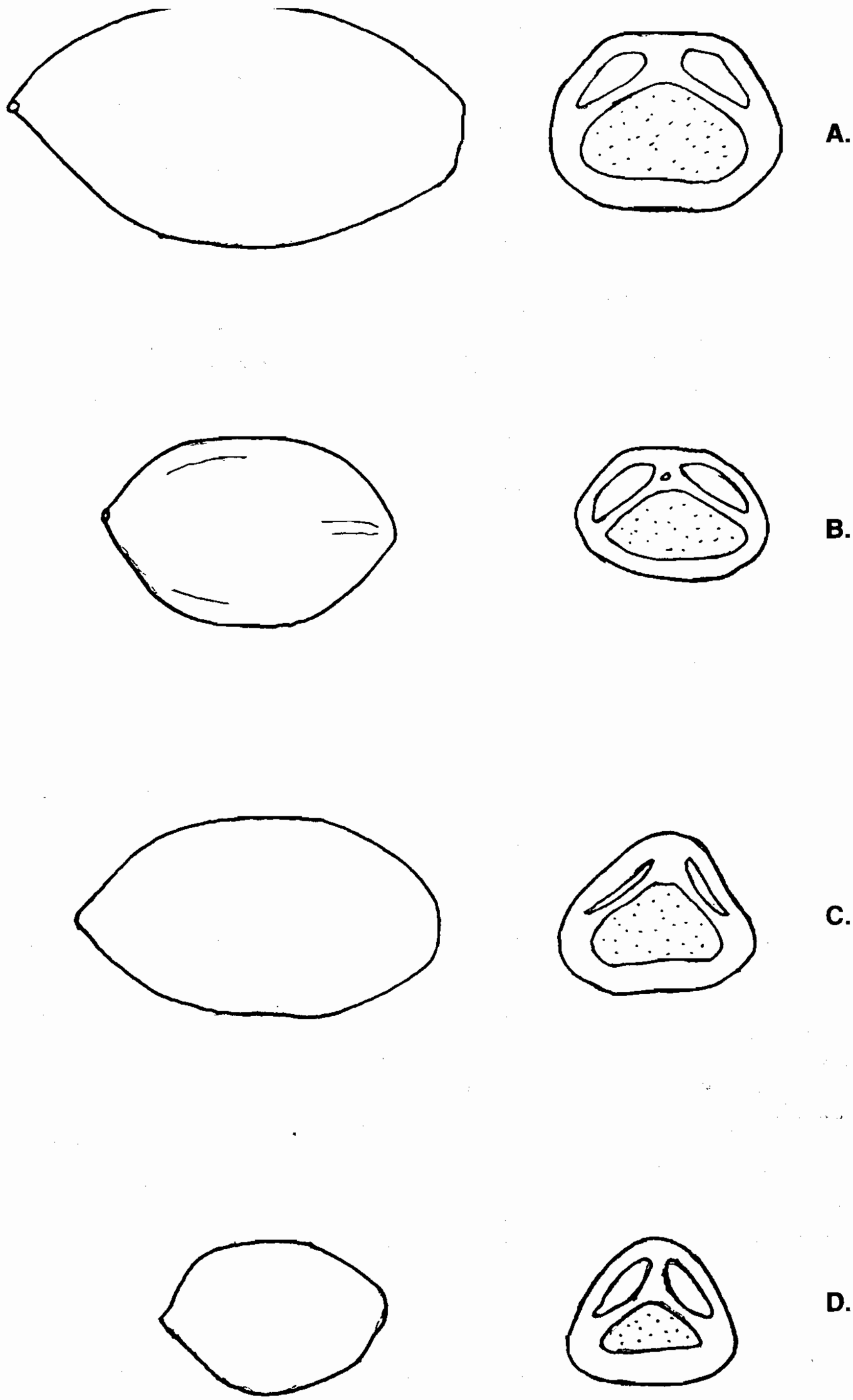


Figure 8: *Canarium indicum var. indicum nuts-in-shell shapes (× 1)*
A. *ZAIR2,* **B.** *SANG1,* **C.** *GIZO1,* **D.** *SALA1*

A.

B.

Plate 10: **A.** (× 0.7) + **B.** (× 0.46) *Canarium harveyi* var. *nova-hebridiense*

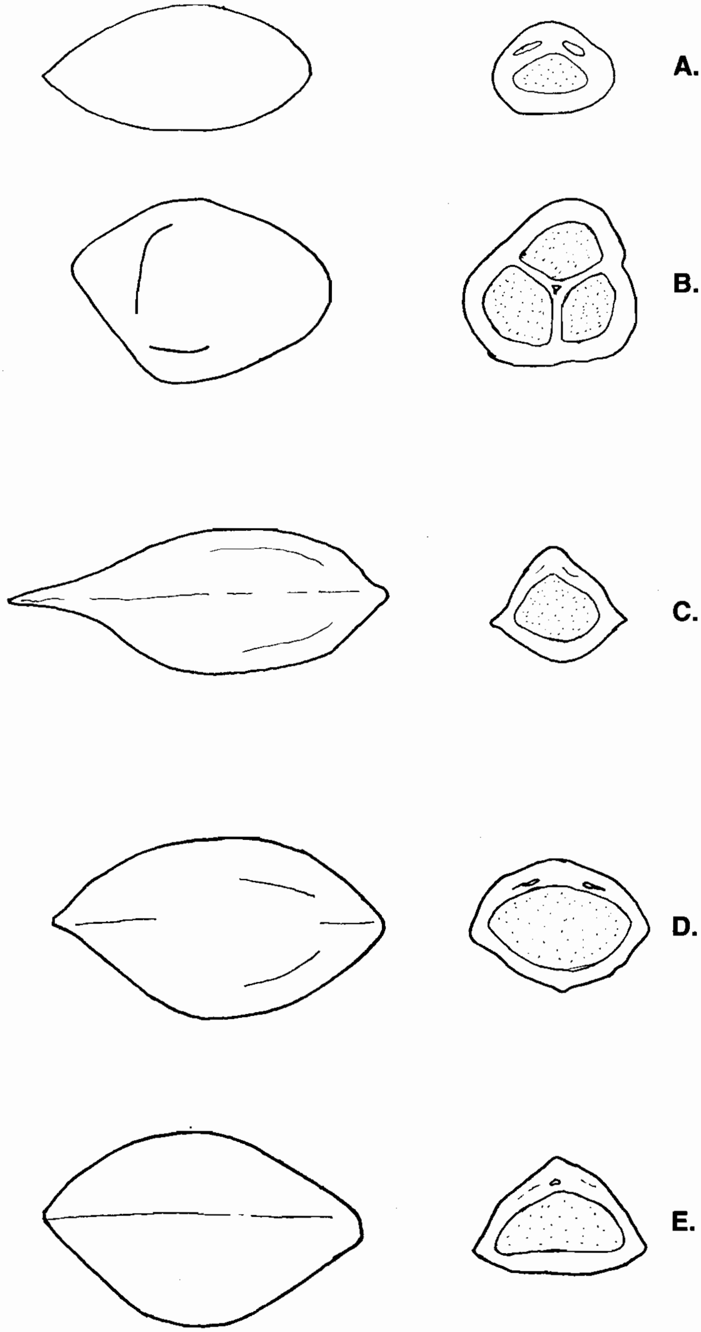


Figure 9: *Canarium harveyi nut-in-shell shapes (× 0.7)*
A. *var. sapidum (STAR1)* **B.-E.** *var. nova-hebridiense*
*(***B.** *BAUN1,* **C.** *LATO2,* **D.** *NEOV1,* **E.** *MALO1)*

Ease of opening the nut-in-shell

Five morphological features *may* be responsible for a nut-in-shell (NIS) being easy to open:

1. Size. Bigger NIS are easier to hold without damaging the fingers.
2. The shape, particularly cross section, of the NIS may affect its structural strength and hence its resistance to a blow on the side (generally used for CANHAR) or micropyle apex (generally used for CANIND).
3. Shell thickness, especially at the edges of the lid.
4. Orientation and size of cells along the edges of the outer endocarp/shell (Juliano 1936).
5. The extension of the inner shell in to the outer shell. This forms a hairline crack along the outer boundary of the lid (Figure 10).

A number of *Canarium* specimens were described by local people as having easy to open shells. In the majority of cases, this was found to be true, but an objective cross assessment proved difficult as it was not possible to compare all NIS at the same time.

Close inspection of the shells of easy-to-open specimens did not reveal any clear common inter- or intra-species morphological characteristics.

CANHAR are generally easier to open than CANIND or CANSAL; an observation confirmed by the higher cracking rates achieved during commercial processing (Evans 1991c).

CANHAR are usually opened by a blow to the side. One reason for this is the acute angles of the 2-sided cross section of CANHAR, which is weaker than the less acute angles formed from the generally 3 or 6-sided round shape of CANIND (c.f., Figures 7 a/b with 7 c/d). It is also easier to hold CANHAR on their side without damaging the fingers because of their greater width (Table 11).

CANSAL are generally opened by standing the NIS hilum end down and hitting the micropyle end. This is not because they are easier to open this way, it is simply a way of preserving the fingers by holding on to the longest axis; children with small fingers often strike CANSAL on their side to open them.

The average shell thickness of CANHAR was slightly less than CANIND (Table 12), but a number of individual specimens of CANIND from the WP (e.g., SANG1 and BANI1) had shell thicknesses nearly 1 mm less than the minimum found in CANHAR, making them very easy to crack.

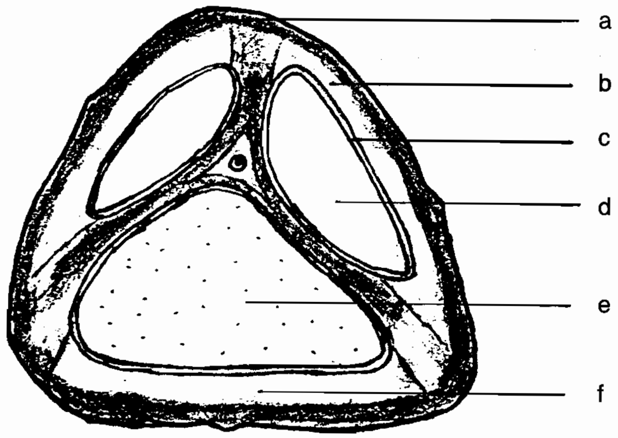
In general, CANIND from the WP had shells 20% (approximately 1 mm) thinner than those from other provinces (Table 12, Plate 8b), making them noticeably easier to crack.

Correlation analysis

Correlations existed between *Canarium* nut-in-shell length/width/circumference/size and nut-in-shell/kernel-in-testa weight for CANIND and CANHAR (Table 13). No correlation was found between any of the nut-in-shell characters and K:N ratio.

Analysis of a far greater number of nuts from the 1990 commercial supply showed similar results.

Nut-in-shell weight was the most suitable and easily measured nut-in-shell characteristic for predicting kernel-in-testa weight. If weight cannot be measured, NIS circumference is the next most accurate predictor. In similar work, Coronel and Zuno (1980a) found fruit diameter to be the most reliable indicator of kernel weight for Pili nuts (*Canarium ovatum*) in the Philippines, but, as with ngali nuts, K:N ratio could not be predicted using physical characteristics.



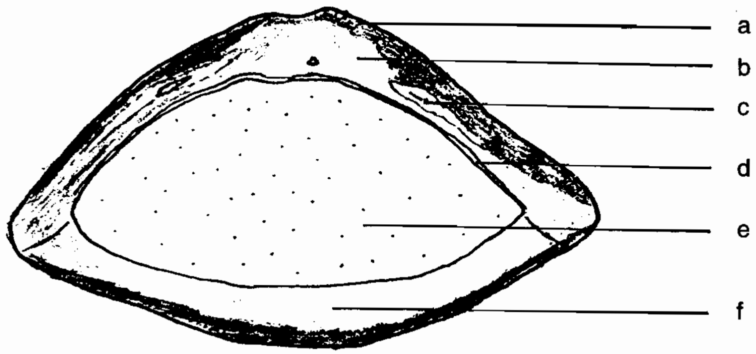


Figure 10: Cross section of *Canarium* spp. nut-in-shell.
A. *Canarium indicum* var. indicum (ZAIR1) (× 1.7)
B. *C. harveyi* var. *nova-hebridiense* (LONE1) (× 2.3)
a) outer endocarp/shell, b) inner endocarp, c) cell wall + testa, d) sterile cell,
e) kernel/seed, f) lid/valve.

Kernel oil analysis

The average oil content of *Canarium* kernels was 74%, of which 48% was saturated fat (Table 14). The types of fatty acids found are similar to that of palm oil, but with higher levels of stearic and linoleic acids. The low level of linolenic acid should provide good resistance to oxidative rancidity (Harris pers. comm.).

The composition of fatty acids between species was similar, except for levels of oleic and linoleic acid. The lower level of linoleic acid in CANIND and CANSAL should result in better keeping qualities and resistance to the development of off-flavours in kernels during storage (Hammonds pers. comm.).

A greater discussion on the composition and potential uses of *Canarium* kernel oil is given in Evans (1991b).

Table 13. Correlation coefficients of *Canarium* nuts.

Origin of nuts/character	Sample correlation coefficient (r) *C. indicum*	*C. harveyi*
Samples from variety collection		
NIS[1]length × NIS weight	.39**	.54**
× KIT[2]weight	.44**	.53**
× K:N[3]ratio	N.S.[4]	N.S.
NIS width × NIS weight	.60**	.54**
× KIT weight	.46**	.60**
× K:N ratio	N.S.	N.S.
NIS circum × NIS weight	.72**	.73**
× KIT weight	.47**	.63**
× K:N ratio	N.S.	N.S.
NIS size[5] × NIS weight	.69**	.75**
× KIT weight	.51**	.66**
× K:N ratio	N.S.	N.S.
NIS weight × KIT weight	.67**	.80**
× K:N ratio	N.S.	N.S.
Samples from 1990 commercial harvest		
NIS weight × KIT weight	.80**	
× K:N ratio	N.S.	N.S.

Notes:
** Significant at the 1% level.
1. Nut-in-Shell
2. Kernel-in-Testa
3. Kernel/Nut ratio; proportion of NIS that is KIT
4. Not significant at the 5% level
5. NIS size = NIS length + NIS width + NIS circumference

Table 14. Kernel oil analysis of *Canarium* spp.

Test		*C. harveyi* (%)	*C. indicum* (%)	*C. salomonense* (%)
Total oil content[1]		73.6	74.9	73.6
Free fatty acid content		0.1	0.2	
Fatty acid composition				
Lauric	(C12:0)		0.4	
Myristic	(C14:0)	0.1	0.2	
Palmitic	(C16:0)	36.6	34.3	34.9
Palmitoleic	(C16:1)	0.7	0.4	
Heptadecanoic	(C17:0)	0.1	0.2	
Stearic	(C18:0)	10.7	13.4	12.6
Oleic	(C18:1)	26.3	37.5	41.6
Linoleic	(C18:2)	24.5	13.5	10.3
Linolenic	(C18:3)	0.3	0.3	0.4
Arachidic	(C20:0)	0.3	0.3	0.2
Eicosenoic	(C20:1)	0.1	0.1	
Behenic	(C22:0)	0.1		
Saturated		47.9	48.5	47.7
Monounsaturated		27.2	37.8	41.6
Polyunsaturated		24.8	13.7	10.7

Notes:
1. Average of 10 varieties for *C. harveyi* and *C. indicum* one sample for *C. salomonense*

4.6.2 Terminalia

The average and maximum size of TERCAT and TERKAE fruits collected are given in Table 15. The fruits and kernels of TERKAE are generally bigger (especially broader) than those of TERCAT. Chaplin (1985) found the fruits and kernels of TERKAE to be nearly 10 times the weight of TERCAT.

A number of large fruited TERCAT forms (a result of selection) were observed on the Reef Islands, TEM.

A detailed analysis of TERKAE and TERCAT kernel oil is given by Clark et al. (1951).

Table 15. Size of *Terminalia* fruits in ENTC collection.

Species =	TERCAT		TERKAE		*Terminalia*	
	Av.	Max.	**Av.**	Max.	**Av.**	Max.
Size analysis (mm)						
Fruit						
length	**85**	90	**78**	90	**80**	90
width	**53**	55	**55**	60	**54**	60
circumference	**135**	140	**170**	190	**153**	190
Kernel-in-testa						
length	**45**	50		50	**45**	50
width	**15**	15	**21**	24	**19**	24
circumference	**43**	45	**n.a.**	n.a.	**43**	45

4.6.3 Barringtonia

BAREDU and BARNOV fruits were longer and heavier than BARPRO but the three species had near the same KIT weights giving BARPRO a much greater K:N ratio (Table 16). BARPRO fruits appear rounded and broad (fruit circumference > 2 × length) compared to the elongated (length nearly 2 × fruit width) cylindrical shape of BAREDU and BARNOV.

BARNOV fruits are often distinguishable by the presence of four hooked appendages at the base of the fruit (the hooks are part of the endocarp, but sometimes the swollen mesocarp masks them) and a persistent tapering pedicel (BAREDU and BARPRO have sessile fruits).

Although fruit *shapes* differed significantly *within* species, it was not possible to group them satisfactorily because of variations in the moisture content and age of the fruits and a lack of opportunity to compare them simultaneously and objectively.

All species had cultivars with thin pericarps which local people described as easy-to-open.

Similarly, all three species had green and purple fruited cultivars (Table 7) and, in the case of BAREDU and BARPRO, a distinctive green fruited + purple (anthocyanin) endocarp form (Plate 6A).

Table 16. Size and weight of *Barringtonia* fruits in ENTC collection.

	BAREDU		BARNOV		BARPRO		*Barringtonia*	
	Av.	Max.	**Av.**	Max.	**Av.**	Max.	**Av.**	Max.
Size analysis (mm)								
Fruit								
length	**86**	106	**86**	99	**65**	70	**79**	106
width	**44**	47	**42**	50	**43**	48	**43**	50
circumference	**145**	160	**134**	170	**142**	160	**141**	170
Kernel-in-Testa								
length	**44**	54	**45**	55	**36**	40	**41**	55
width	**23**	25	**20**	25	**23**	30	**22**	30
circumference	**78**	80	**50**	50	**70**	76	**71**	80
Weight analysis (g)								
Fruit	**99.1**	129.0	**91.0**	91.0	**60.9**	65.8	**83.8**	129.0
Kernel-in-Testa	**5.0**	8.6	**3.7**	3.8	**5.5**	6.8	**5.1**	8.6
K:N Ratio[1]	**4.5**	7.0	**3.9**	4.0	**9.0**	10.0	**6.4**	10.0

Notes:
[1] Percentage weight of fruit that is KIT.

5. DISCUSSION

5.1 Taxonomy

5.1.1 *Canarium*

The confirmation that Santa Cruz ngali nut is not a localised cultivar of CANIND but rather a separate species and variety clears a long misunderstanding about its taxonomy in the literature.

In most of its vegetative, floral and fruiting characteristics, CANHAR is similar to CANSAL. The fruits, in particular, appear to be large cultivars of CANSAL. CANHAR may be a cultivated race (or hybrid) of CANSAL developed from the more intensive arboricultural systems of the smaller islands on the eastern border of CANSALs geographical range. Yen (1974) came to the same conclusion while trying to identify Santa Cruz ngali nut (see also Yen 1990).

The discovery that CANHAR is polygamodioecious, not dioecious, is consistent with similar observations in Vanuatu (Walter et al. 1993) and the fact that the local people of the Reef Islands, Santa Cruz (which are isolated by more than 50 miles of water from the nearest land mass) know of no male-only flowered trees (androecious) on their islands or indeed have no name for a ngali nut 'man tree' in their otherwise comprehensive botanical vocabulary. It also explains why isolated single planted trees produce fruit and the observed large variation in yield between trees and over time. The change in floral sex over time (Fig. 4) highlights the difficulties involved in describing floral biology from static herbaria material. A few other species within Burseraceae have been found to be monoecious (Leenhouts 1956) and other *Canarium* species, such as *C. pilosum* (Leenhouts 1959) and *C. ovatum*, have occasionally been found with fruit and hermaphrodite flowers on male flowered trees (andromonecious).

The change in the floral biology of CANHAR may be a result of selection over time. In the intensive arboricultural systems found in the Santa Cruz Islands, it could be expected that male-only trees would be culled in favour of fruit producing female flowered trees. Over time, this would lead to the selection of female flowered trees and, to a lesser extent, male trees with some fruit producing hermaphrodite flowers (which may occur periodically through outcrossing and mutation).

These results have important implications for any future breeding or plantation work. For example, cultivars of CANHAR may reproduce true-to-type trees via seed and the need to over plant in order to achieve appropriate male-female ratios in plantations may be less important for CANHAR than in other species[1].

Further, more detailed, research is needed on all aspects of the floral biology of cultivated edible *Canarium* spp.

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1 Subsequent field observations in neighbouring PNG and Vanuatu have indicated that CANIND is also polygamodioecious.

5.1.2 *Barringtonia*

Many of the *Barringtonia* cultivars found in this collection closely resemble those found in PNG and Vanuatu by Jebb (1992) and Walter and Sam (1992a, 1993), respectively.

The results confirm what has long been suspected that the distribution and variability of BAREDU far exceeds that given by Payens (1967).

The existing taxonomic status of BAREDU is also questionable. Observations by the author in Fiji suggest that the BAREDU found there is far from uniform; a brief survey found trees with large differences in key taxonomic characteristics such as petiole and pedicel length. Fruit shape and size was also noticeably different to that found in Solomon Islands and PNG. The work of Jebb (1992) in PNG and the on-going work of Walter and Sam in Vanuatu has undoubtedly helped an understanding of edible *Barringtonia*, particularly the variability in edible species due to cultivation, but any rearrangement of the genus' taxonomy will not be possible until a comprehensive comparison of material is made from all of Melanesia.

5.2 Fruit morphology

5.2.1 *Canarium*

The size of the CANHAR fruits collected in this survey agree with those given by Yen (1974) and far exceed those previously recorded for the species by Leenhouts (1959).

The NIS weight of the CANHAR and CANIND collected in Solomon Islands is 100% and 61% heavier respectively than the weight of Pili nuts (*Canarium ovatum*) from the Philippines where NIS average 7.7 g (maximum = 9.5 g) and KIT average 1.7 g (maximum = 1.8 g) to give a K:N ratio of 22% (maximum = 25%) (Armour 1965). The best cultivars of *C. ovatum* planted at the University of Hawaii have NIS averaging 12.0 g (same as average CANIND) and kernels 3.0 g (Hamilton pers. comm.) resulting in a K:N ratio of 25%; about the same as CANHAR in Solomon Islands (Table 11).

CANHAR fruits and kernels are also larger than those of *C. megalanthum* Merril which is cultivated in Brunei for its edible kernels and which is described by Leenhouts (1959) as having fruits 'among the largest in the genus'.

The lack of variation found in CANSAL contrasts strongly with the observations of Walker (1948, 1962), who found a large number of varieties, and suggests that his comments may have referred to CANIND.

The NIS characteristics of CANHAR are far superior to that of CANIND and CANSAL; the NIS are bigger, generally easier to crack and have a higher K:N ratio. However, the *observed* NIS yield per tree of CANHAR is far less than the *recorded* average yield of CANIND (113 kg/NIS/yr, maximum = 317 kg [Chaplin and Poa 1988]). Furthermore, some of the better CANIND specimens collected in this survey (and doubtless many more yet to be found), especially those in Western Province, are near equal to average CANHAR in NIS size and K:N ratio.

It is concluded, therefore, that future development should concentrate on CANIND because of its higher yield and far greater existing distribution and adaptation.

The uniform size and shape of CANSAL should make them a better prospect for mechanical deshelling.

5.2.2 *Barringtonia*

The average size of Barringtonia fruits were almost identical to those found in PNG (Jebb 1992). BARPRO fruits in Solomon Islands are also a similar size to those found in Vanuatu, but the BAREDU and BARNOV found in Solomon Islands (Table 16) are significantly longer and thinner than those in Vanuatu (BAREDU = 78 × 51 mm, BARNOV = 65 × 53 mm, Walter and Sam 1992b).

5.3 Classification of *Canarium* nuts-in-shell

Table 17 gives details of a system for the classification of the three *Canarium* taxa collected in to seven forms and five grades, based upon NIS characteristics.

The classification is based upon distinctive and easy to measure *NIS* characteristics. *Fruit* characteristics were not used because of their inherent variability due to moisture content.

Details of the 7 forms are as follows:

NUT-IN-SHELL SHAPE: **forms *elongated*** and ***broad***

Both forms are *relative and independent of size*; hence a specimen with a NIS length well below average can still be form *elongated* so long as its length is twice its width. Both forms can be identified in the field with the use of a ruler and string (to measure circumference).

Table 17. A system for the classification of edible *Canarium* in Solomon Islands by nut-in-shell characteristics.

Character	Form/Grade	Code	Definition	See Figure	See Plate
NIS[1] shape	Elongated	El	NIS length >2 × NIS width	11, 7e	8b(ix)(xiv)
	Broad	Br	NIS circum. > 2 × NIS length	11, 9, 9b	8b(iv)(vii)(viii)
Shell colour	Black	Bl	Deep and in most NIS uniform colouring		8b(ix) 9b(ix)
NIS cross section	Triangular	Tr	3-sided sharp angles	12, 7a, 9e	8b(vi), 8a(i)
	Hexangular	Hx	6-sided, often with 2 sides rounded, but open side always flat. NIS will rest on apex of flat side.	12	8b(vii)(viii), 1a
Seed number	Biseeded	Bi	More than 50% of NIS per tree with 2 seeds per NIS	12 9b	8b(i) 10a
	Triseeded	Ts	More than 50% of NIS per tree with 3 seeds per NIS		
K:N[2] ratio	First grade	1	K:N ratio >25%		
	Second grade	2	K:N ratio 21%–25%		
	Third grade	3	K:N ratio 16%–20%		
	Fourth grade	4	K:N ratio 10%–15%		
	Reject	R	K:N ratio <10%		

Notes:

[1] Nut-in-shell.

[2] Kerner:nut ratio; proportion of NIS that is KIT.

SHELL COLOUR: **form *black***

The deep pigmentation of the shell, probably caused by anthocyanin accumulation, is very distinctive and well known by local people (e.g., the vernacular 'Okete Davala' means *Canarium indicum* black in Roviana, New Georgia). In field notes, it is often described as deep purple or deep cherry red etc., but the distinction is rather subjective so the term black is used. The size, taste or grade of a nut is not affected by it being black shelled.

NIS CROSS SECTION: **forms *triangular*** and ***hexangular***

The NIS must be cut in half for an accurate assessment of cross sectional shape.

Only those NIS with a clear, sharp angled triangular cross section (cross section) should be classified as form *triangular*. The whole NIS should be able to rest on all three of its sides.

Form *hexangular* often have two out of six sides rounded, but the NIS should always be able to rest on the apex side.

SEED NUMBER: **forms *biseeded*** and ***triseeded***

NIS with two or more fully developed seeds inside often have a distinctive bulborous cross sectional shape, and (again) are well known to local people (e.g., 'Ngari didingo' = *C. indicum* 2 seeds in Arosi, W. Makira).

For accurate assessment, a sample of at least 20 NIS from around the tree should be cracked to inspect seed number. If possible, a further sample should be taken the next year to confirm the results.

Using this system, a little over half of all the *Canarium* specimens measured can be classified in to one or more forms (Table 18, Appendix 1). The remainder cannot be classified because they possess no common, easily measured NIS morphological characteristics which would allow them to be grouped or because their individual characteristics are not distinctive enough to classify them without ambiguity. For example, a number of specimens, mostly belonging to CANHAR, had clear ridges running longitudinally along the upper and lower sides of the NIS (see, for example: LATO2 [Fig. 9c]; PIGE1 [Plate 9b]; and NOPA2 [Fig. 11b]), but it proved impossible to group these because of the quantity (and variation) of marginal cases. Therefore, while ridging is an important *descriptive* feature it cannot be confidently used as a classification character.

One in three CANHAR belong to NIS shape form. *elongated*, compared to one in five for CANIND (Table 19). In contrast, very few CANHAR belonged to form. *broad*, compared to 20% of all CANIND.

CANIND NIS from the Western province were more elongated and less broad than those from other provinces.

The classification of specimens into grades according to K:N ratio[2] enables all specimens to be graded and conforms to standards which were set for the commercial purchasing of nuts from smallholders. These set price dividends for the supply of nuts with high K:N ratios in order to equalise the unit purchase price of kernels, and because it was found that costs of processing (particularly cracking) were very much higher for NIS with a low K:N ratio (Evans 1991c).

In short, K:N ratio is the single most important economic character of an edible *Canarium* NIS.

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2 K:N ratio is the percentage weight of NIS (<5% m.c.) that is dry KIT (<1% m.c.).

Most of the CANHAR specimens collected were graded as either first or second grade. In contrast, just 12% of the CANIND collected belonged to the two higher grades (Table 18). CANIND from the Western province were generally higher grade than those from the other provinces.

These figures correspond with the results from the 1990 nationwide commercial purchase of nuts by CEMA, in which 100% of the CANHAR purchased were graded as first grade, and approximately 2%, 10%, 38% and 50% of all CANIND were graded as first, second, third and fourth grade respectively (Evans 1991c).

The classification of specimens into infraspecific forms and grades allows individual specimens to be described more accurately than previously possible. Both the description of the NIS shape and its economic worth can be standardised to facilitate ease of comparison.

For example, the full description of specimen LAMB1 would be as follows:

LAMB1:	*Canarium indicum* L. var. *indicum* form *broad hexangular* (3rd grade). Or, more verbose:
REF:	LAMB1 (Evans, B.R. 26/4/89. Vella Lavella, Western Province, Solomon Islands)
FAMILY:	Burseraceae
GENUS:	*Canarium*
SPECIES:	*indicum*
SUBSPECIES:	
VARIETY:	*indicum*
FORM:	*broad hexangular*
GRADE:	3

It is hoped that this system will help on-going and future collections in Solomon Islands, and encourage collections in other countries where edible *Canarium* are found.

Table 18. Classification of ENTC *Canarium* collection by nut-in-shell characteristics.

Character	Form/Grade	Code		Percentage of ENTC variety collection in each class				
			Species =	CANIND			CANHAR	CANSAL
			Province =	WP	Other	All	All	All
NIS shape	Elongated	El		26	13	20	36	50
	Broad	Br		16	25	20	4	0
Shell colour	Black	Bl		10	6	8	9	0
NIS cross	Triangular	Tr		15	6	11	6	0
section	Hexangular	Hx		10	18	14	0	0
Seed number	Biseeded	Bi		0	6	3	0	0
	Triseeded	Ts		0	0	0	3	0
Percentage of measured specimens classified in to forms				58	50	54	50	50
K:N ratio	First grade	1		13	0	8	33	0
	Second grade	2		6	0	4	57	50
	Third grade	3		56	20	42	5	50
	Fourth grade	4		13	80	39	5	0
	Reject	R		13	0	8	0	0

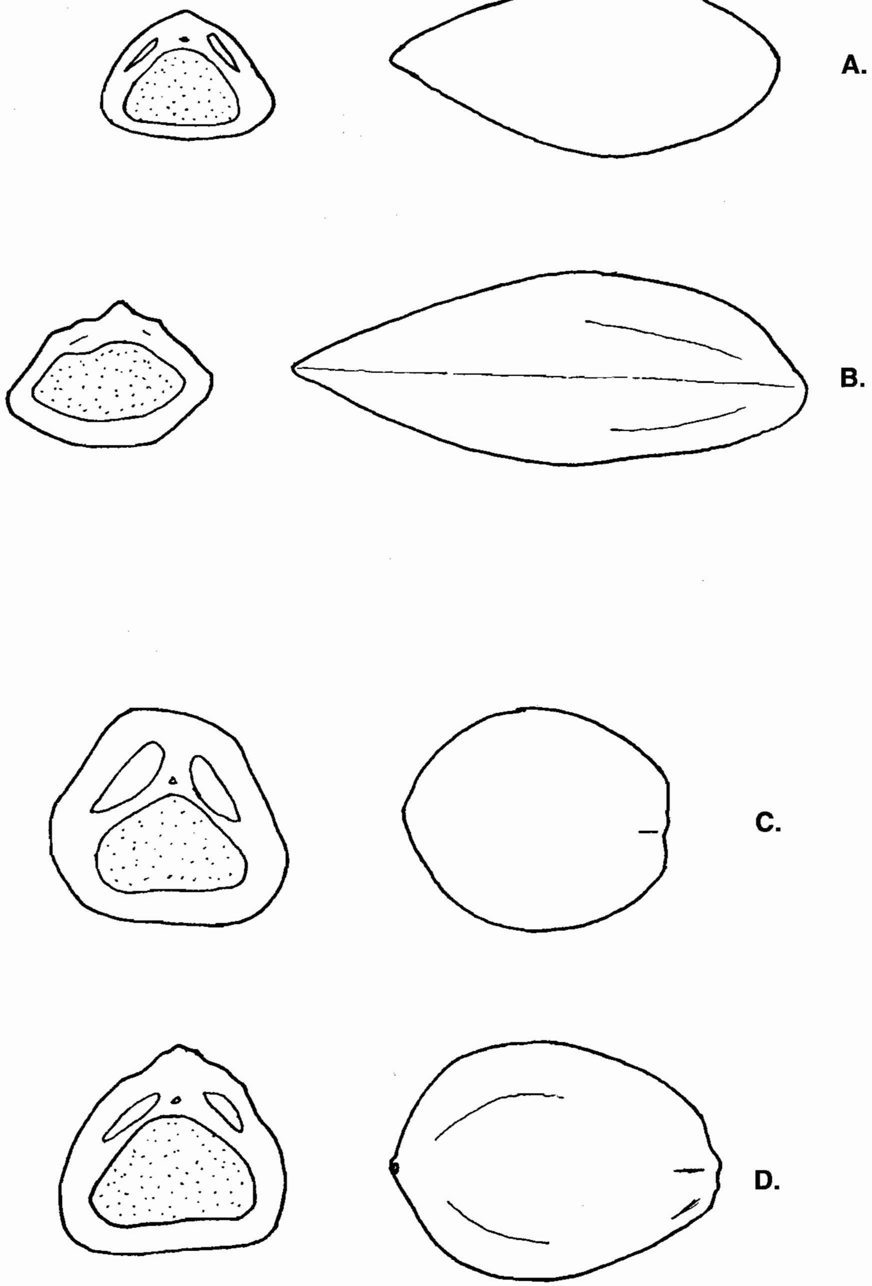

Figure 11: Examples of *Canarium* nuts-in-shell shape form. *elongated* and *broad* (× 0.9).
A. *Canarium indicum* var. *indicum* form. *elongated* (MUND1)
B. *C. harveyi* var. *nova-hebridiense* form. *elongated* (NOPA2)
C. *C. indicum* var. *indicum* form. *broad* (ZAIR1)
D. *C. indicum* var. *indicum* form. *broad* (CHEA1)

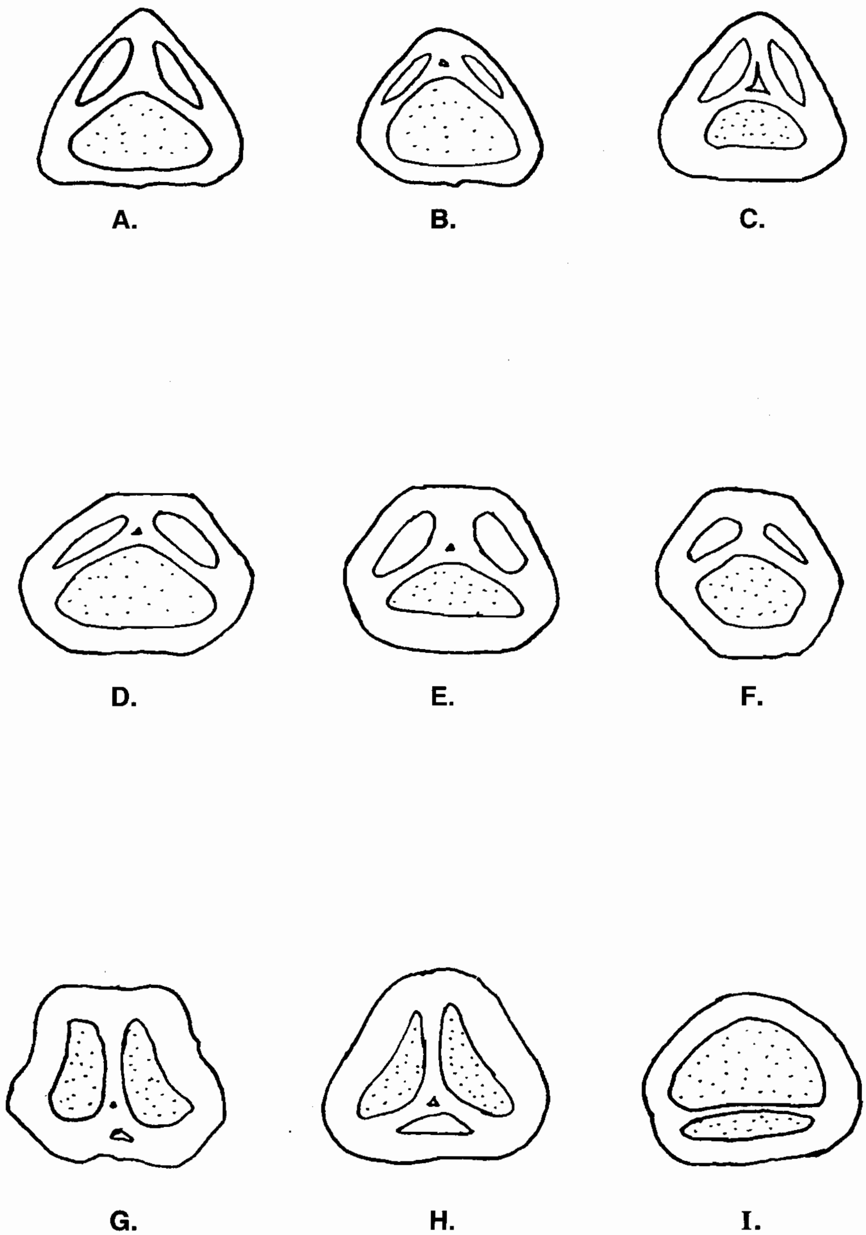

Figure 12: Examples of *Canarium* nuts-in-shell shape form. *triangular* and *hexangular* and seed number form: *biseeded* (×1).
Canarium indicum var. *indicum* form:
triangular (**A.** SIMB2, **B.** BANI1, **C.** SALA4),
form: *hexangular* (**D.** LAMB1, **E.** BEBE1, **F.** BITA1),
form: *biseeded* (**G.** and **H.** unamed [typical shape], **I.** TAWA1 [atypical shape])

5.4 Ranking

All *Canarium* specimens with sufficient data were ranked according to ease of opening the NIS, NIS length, K:N ratio and distinguishing characteristics (Appendix 1)[3].

The rank of a specimen provides a guide to its overall 'desirability'—the higher the rank, the greater the specimen's economic and genetic importance. The ranking system should also help prioritise future collections.

Fifteen of the top 20 ranked specimens were CANHAR (Appendix 1).

NOPA1 a CANHAR from the Reef Islands in TEM is the highest ranked specimen (20.5 points); although its economic characteristics are not outstanding, the genetic value of its unique 5-lobed cotyledon is considered to be very high. In contrast, WIAV1 (CANHAR from Neo Is. TEM) has no notable genetic characteristics, but is ranked second (20.4 points) because of its exceptionally long NIS (average = 80 mm). NEOV3 (ranked third with 19.6 points) scores high on all facets.

The highest ranked CANIND were CHEA1 and SANG1 (joint ninth with 18.0 points each) from Marovo lagoon and Choiseul respectively (both in the Western province); the former mainly because of its very large NIS and the latter because of its high K:N ratio (26% c.f. CANIND av. of 16% [Table 11]) and the genetic and economic importance attached to its thin shell (1.9 mm c.f. CANIND av. of 3.7 mm [Table 12]).

Because of the difficulties in making an objective assessment, the ranking system does not include kernel taste—a critically important economic characteristic. If it did, it is likely that CANIND in general would have been ranked much higher. Most third parties (in particular people of European origin which may be important when considering export marketing) consider the taste of CANIND to be far more palatable than CANHAR.

[3] See section 3.2.3 for details of ranking system.

6. CONCLUSIONS

1. Solomon Islands possess a valuable gene pool of economically important cultivars of *Canarium indicum* and *C. harveyi.*
2. Intra specific variation in *Canarium* and *Barringtonia* nut-in-shell and fruit characteristics respectively have developed over time because of extensive and intensive selection for desirable fruit and tree characteristics by local people.
3. *Canarium harveyi* var. *nova-hebridiense* has evolved through intensive selection from being dioecious to polygamodioecious.
4. *Barringtonia edulis* is commonly cultivated throughout Solomon Islands.
5. Future economic development on *Canarium* should concentrate on *C. indicum* because of its greater yield, genetic diversity and distribution.
6. The nuts-in-shell of edible *Canarium* spp. can be classified by their shape, cross section and colour.

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APPENDIX 1

Primary characteristics of edible nut variety collection

The listings given in Appendices 1.1 and 1.2 are sorted by genus, species and then alphabetically by reference number. The following abbreviations and codes are used

COLUMN HEADING	CONTENTS/UNITS	MEANING/COMMENTS
SPEC.	IND	*Canarium indicum* var. *indicum*
	HAR	*C. harveyi* var. *nova-hebridiense*
	HARsap	*C. harveyi* var. *sapidum*
	SAL	*C. salomonense* ssp. *salomonense*
	BAREDU	*Barringtonia edulis*
	BARNOV	*B. novae-hiberniae*
	BARPRO	*B. procera*
	TERCAT	*Terminalia catappa*
	TERKAE	*T. kaernbachii*
FORM	El	*elongated*
	Br	*broad*
	Bl	*black*
	Tr	*triangular*
	Hx	*hexangular*
	Bi	*biseeded*
	Ts	*triseeded*
GRADE	1–4	First–Fourth grade
RANK		See sect 3.2.3
PROV		Province: See list of abbreviations
CHAR1/2		major/notable characteristics
FRUIT + NIS LEN/WTH/CIRC	(mm)	see Figures 1, 2 and 3
NISWT	(g)	NIS weight (<5% m.c.)
SHELL	(mm)	shell thickness
EASE (0-5)		Ease of opening the NIS. 0 = v. hard 5 = v. easy
FRWT	(g)	Fruit fresh weight
KITWT	(g)	KIT dry weight (<1% m.c.)
K:N (%)	% by weight of NIS/fruit that is KIT	
SKIN	fruit skin colour	

Appendix 1.1. Primary characteristics of *Canarium* ENTC collection.

REF	SPEC	FORM	GRADE	RANK	PROV	ISLAND	CHAR 1	CHAR 2	NISL EN	NISW TH	NISC IRC	NIS WT	SHE LL	EAS E	NIS SHAPE	KIT WT	K: N
BAUN1	HAR	Br/Ts	4	15.5	TEM	Lomlom/Reefs	fruit shape	polyembryonic	45	33	110	18.6	3.5		v. rounded 3 ribbed	2.2	12
CRUZ1	HAR			1.0	TEM	Santa Cruz	nut shape								sharp edges		
DALA1	HAR		2	15.5	MAL	Malaita	fruit shape		60	35	75	11.3	3.1			2.8	25
LATO2	HAR	El	2	19.8	TEM	Lomlom/Reefs	easy to open		67	25	70	13.0	3.5		5 cnrd at micropyle	2.8	23
LIPE1	HAR			18.4	TEM	Lomlom/Reefs	kernel taste	sweet not oily									
LIPE2	HAR			1.0	TEM												
LONE1	HAR		1	14.8	TEM	Neo	fruit shape		50	34	87	13.8	3.1	4.00	ovate	3.7	27
MALA2	HAR	El/Tr	2	14.8	TEM	Fenualao	nut shape		68	33	90	20.9	3.9	3.00	convex at hilum end	4.4	21
MALO1	HAR	Tr	2	16.7	TEM	Neo	fruit size		60	33	90	15.5	3.5		angular	3.5	23
MALO2	HAR		2	16.3	TEM	Neo	fruit shape	kernel oil	62	32	83	16.9	3.8		flat on top	3.8	23
MBEA1	HAR		1	16.2	TEM	Nendo	fruit shape		62	34	90	18.4		4.00	upturned hilum	4.8	26
NEOV1	HAR		1	17.0	TEM	Neo	fruit shape		58	34	90	17.7	2.8	4.00	broad. 1 × rib	5.7	32
NEOV2	HAR		2	18.7	TEM	Neo	fruit shape	kernel taste	66	35	87	19.6	3.5			4.5	23
NEOV3	HAR		1	19.6	TEM	Neo	kernel taste		70	40	95	20.1	3.5	4.00	heavily ridged.	5.7	28
NEOV4	HAR			15.6	TEM	Neo			70	40	90			4.00	thin/flat/ridged		
NEOV5	HAR		1	18.6	TEM	Neo			58	36	87	14.6	3.2	4.00	oval-w/heavy ridge	4.2	29
NEOV6	HAR			14.6	TEM	Neo	fruit colour		60	38	95			4.00	v.wide, fairly thick		
NEOV7	HAR			1.0	TEM												
NIMO1	HAR				TEM												
NIMO2	HAR				TEM												
NIVA1	HAR	Bl		15.9	TEM	Lomlom/Reefs	shell colour										
NOPA1	HAR	El	2	20.5	TEM	Lomlom/Reefs	kernel leaf no.		68	33		13.7				4.0	22
NOPA2	HAR	El	1	17.5	TEM	Lomlom/Reefs	fruit shape		75	30	83	17.6	4.0	4.00	ribbed	4.7	27
NOPA3	HAR		2	16.6	TEM	Lomlom/Reefs	fruit shape		58	32	83	15.1	3.5	4.00	hump on underside	3.8	25
NOPA4	HAR			15.4	TEM	Lomlom/Reefs	fruit shape	fruit season									
NOPA5	HAR			16.9	TEM	Lomlom/Reefs	kernel taste		56	32	82	15.0			winged x-sect		
NOPA6	HAR			1.0	TEM												
OTAM1	HAR	El/Bl	2	14.5	TEM	Lomlom/Reefs	fruit shape		55	23	65	11.1	3.0	3.00		2.8	25
OTEL1	HAR	El	2	18.4	TEM	Lomlom/Reefs	easy to open		61	28	74	13.3	3.3		thin elongated	3.3	25
OTEL2	HAR		3	13.0	TEM	Lomlom/Reefs	fruit size		50	31	82	12.0	3.2	4.00	5 corner micropyle	2.0	17
OTEL5	HAR			1.0	TEM	Lomlom											
PIGE1	HAR	El	1	15.9	TEM	Pigeon/Reefs	fruit shape		65	32	85	15.8	3.2	3.00	rib upperside	4.4	28
TENG1	HAR	Bl	2	13.9	TEM	Fenualoa/Reefs	nut colour		51	31	81	12.8		3.00	upturned hilum	3.2	25
WIAV1	HAR	El	2	20.4	TEM	Neo	nut size	kernel taste	80	37	85	18.3		4.00	long/curve from end	4.7	22
STAR1	HARsap	El		14.1	MAK	Makira	fruit shape		48	22	67	8.7	2.6				
BABA1	IND		4	11.1	GC	Guadalcanal	fruit size		45	30	85	10.3		2.00	angular/wide	0.9	11

Appendix 1.1. (continued) Primary characteristics of *Canarium* ENTC collection.

BANI1	IND	Tr/El	2	17.5	WP	Rendova	nut easy open		47	23	70	9.8	2.5	4.00	3 side triangular	2.2	23
BARA5	IND	Hx	4	12.8	WP	Honiavase	fruit shape		50	27	85	13.0	3.6	4.00	oblong/angular	2.0	15
BEBE1	IND	Hx/Br	4	10.4	GC	Guadalcanal	fruit shape	fruit season	40	29	90	14.3	4.6	2.00	6-sided X-sect	1.8	13
BITA1	IND	Hx/El/B	4	11.3	MAL	Malaita	nut colour		45	22	74	11.3		3.00	angular, Ovoid	1.7	15
BUAL1	IND	Hx/Br	3	13.5	ISA	Isabel	fruit season		40	27	84	12.2		3.00	v.round	1.9	16
CHEA1	IND	Br		18.0	WP	Marovo/Vangunu	nut size	nut easy open	48	33	100	17.1	4.2	5.00	3 side round		
CHEA2	IND			14.2	WP	Marovo/Vangunu	fruit size										
FOON2	IND		4	10.2	MAL	Malaita	nut hard open		46	23	71	9.8		1.00	med-rounded	1.3	13
FOON3	IND	Br	4	14.5	MAL	Malaita	nut easy open		35	27	77	9.4		4.00	rounded triangular	1.4	15
FOON6	IND	El		14.7	MAL	Malaita			62	27	80				triangular ribbed		
GIZO2	IND		3	14.4	WP	Ghizo	fruit size		54	30	85	15.7		3.00	angular/flat top	2.5	16
GIZO3	IND	Tr	3	13.8	WP	Ghizo	fruit size		50	30	83	13.3		2.00	slim/oblong-angular	2.7	20
KALE1	IND			16.2	ISA	Isabel	kernel size		50	30	90			4.00			
KORI1	IND		3	15.5	WP	Ranongga	fruit size	kernel dev	47	28	83	13.4		4.00	3 sided micropyle	2.5	19
LALE1	IND			14.8	WP	Ranongga	fruit size		53	25	77	15.4	3.7		long/round 3 sided		
LAMB1	IND	Hx/Br	3	12.6	WP	Vella Lavella	fruit shape		41	28	83	12.3			v flat base. 6 sided	2.0	16
LOKU1	IND	Bl	1	16.2	WP	Rendova	shell colour		47	25	80	9.8	2.9	3.00		2.6	27
MAGA1	IND			15.0	ISA	Isabel	kernel taste		45	27	85		4.2				
MUND1	IND	El	3	12.8	WP	New Georgia	fruit shape		53	25	77	11.3			sharp angular/3 side	1.9	17
NUAT1	IND		3	16.5	WP	Choiseul	Mesocarp peel		47	27	74	11.1	3.1	3.00		1.9	17
ONEI1	IND			10.2	MAK	Makira	fruit shape		40	23	70	8.3		2.00			
PENJ1	IND		R	14.2	WP	Nggatokae	fruit size		50	27	80	11.0	3.2	3.00	3 sided round	1.0	9
POIT1	IND	El/Bl	R	11.3	WP	Kolombangara	shell colour		50	20	80	14.0			rounded/angular	1.3	9
SALA1	IND	Br	4	10.0	GC	Guadalcanal			28	22	70	7.7			3 sided rounded	0.9	12
SALA2	IND			11.6	GC	Guadalcanal	nut shape		41	21	65	8.5	4.1		3 sided rounded		
SALA3	IND			12.2	GC	Guadalcanal											
SALA4	IND	Tr	4	11.7	GC	Guadalcanal	nut size		48	25	80	12.0			strong 3 sided long	1.5	13
SANG1	IND		1	18.0	WP	Choiseul	shell thickness		40	26	75	6.9	1.9	5.00		1.8	26
SAVO1	IND		3	12.2	CIP	Savo			50	26	80	13.3	4.6	3.00		2.1	16
SIMB1	IND	El	3	15.4	WP	Simbo	fruit size		55	27	80	12.5			3 sided	2.3	18
SIMB2	IND	Tr/El		14.1	WP	Simbo	fruit easy open		58	28	83	15.7			x-sect triang/long		
TAWA1	IND	Bi		15.9	MAK	Makira	kernel number		43	25	85	7.8		3.00	rounded		
VARE1	IND		3	16.1	WP	Vella Lavella	fruit size		52	28	85	17.5			3 side v.round edge	3.2	18
WEIL3	IND		4	14.8	MAL	Small Malaita	fruit easy open		42	27	77	13.2	4.0	4.00	tri x-sect	1.8	14
ZAIR1	IND	Br	4	12.8	WP	Vangunu	nut shape		40	35	110	18.2	4.9	4.00	v. wide/round/short	2.5	14
ZAIR2	IND		3	16.4	WP	Vangunu	nut size		54	31	100	20.0	3.6	4.00	rounded, 3 sided	4.0	20
LOKU2	SAL	El	2	12.9	WP	Rendova			37	18	50	4.2		4.00		0.9	21
MATA2	SAL		3	10.5	MAL	Small Malaita			33	19	58	5.5		3.00	rounded, 2 sided flat	0.9	16

Appendix 1.2. Primary characteristics of Barringtonia and Terminalia ENTC collection.

REF	SPEC	PROV	ISLAND	CHAR 1	FR LEN	FR WTH	FR CIRC	FR SHAPE	SKIN COL	FR WT	KITWT	K:N
GIZO4	BAREDU	WP	Ghizo	fruit colour	65	40			green	63.0	1.8	3
NGAM1	BAREDU	TEM	Lomlom/Reefs	fruit colour/ hard open	75	45	140	bulborous at apex	green			
NGAM2	BAREDU	TEM	Lomlom/Reefs	fruit colour/ easy open	80	40	125	8 sided X-sect	purple			
PALA2	BAREDU	MAL	Small Malaita	fruit size	100	47	150	elongated	purple	129.0	8.2	6
UGUL1	BAREDU	WP	Rendova	fruit freq/size	106	44	160	cylindricle	purple	125.5	8.6	7
WEIL2	BAREDU	MAL	Small Malaita	fruit size	90	45	150	elongated	green	79.0	1.5	2
BARA4	BARNOV	WP	Honiavasa	fruit size	90	50	150	elongate	purple	91.0	3.8	
MALA1	BARNOV	TEM	Fenualoa/Reefs	fruit colour	99	50	170	ovoid, bulborous end	purp/grey			
MARA1	BARNOV	MAK	Makira	fruit shape	99	32	105	banana	green			
PALA4	BARNOV	MAL	Small Malaita	tree yield?	55	35	110		green			
LALE2	BARPRO	WP	Ranongga	tree size	68	40	130	trucated ovoid	green			
MUND5	BARPRO	WP	New Georgia	fruit easy open	58	48	155	rounded	green			
PALA1	BARPRO	MAL	Small Malaita	tree size dwarf	65	48	160	rounded. flat ends	green	60.0	3.9	7
PALA3	BARPRO	MAL	Small Malaita	fruit colour	70	37	130		green	57.0	5.8	10
WEIL1	BARPRO	MAL	Small Malaita		63	40	133	ovate. Blunt ends	grey/purple	65.8	6.8	10
HONI1	TERCAT	GC	Guadalcanal									
OTEL3	TERCAT	TEM	Lomlom/Reefs	endocarp colour	80	50	130	ovoid	l. green			
OTEL4	TERCAT	TEM	Lomlom/Reefs	fruit size	90	55	140	x-sect winged	d. green			
IRIN1	TERKAE	WP	Vella Lavella		70	50	150	rounded.	Red			
IRIR1	TERKAE	WP	Kolombangara									
LOKU3	TERKAE	WP	Rendova						Red			
MUND4	TERKAE	WP	New Georgia									
STAR2	TERKAE	MAK	Makira		40	60	190		red			

APPENDIX 2

DESCRIPTION OF SANTA CRUZ NGALI NUT

***Canarium harveyi* Seem. var. *nova-hebridiense* Leenh.** Bishop Mus. Bull. 216: 37, Fig. 15j,l, 16c (1955), in Blumea 9(2): 356-357 (1959). *C.* sp. nov. Guillaumin, A., J. Arnold Arb. 12: 237, Fig. 2B (1931).

Synonyms

None known.

Vernaculars

'Santa Cruz Ngali nut' (Solomon Islands Pidgin), 'Nyinga' (Ayiwo, Reef Is., Santa Cruz), 'Nolepo' (Graciosa Bay, Nendo, Santa Cruz), 'Nange d' (Mota Lava, Banks Is, Vanuatu).

Distribution

Santa Cruz (Solomon Islands) and Banks (Vanuatu) Islands. Occasionally planted in other provinces of both countries.

Cultivars/Forms

elongated form nov.	Nut-in-shell(NIS) length more than twice NIS width
broad form nov.	NIS circumference more than twice NIS width
triangular form nov.	NIS cross section 3-sided
triseeded form nov.	Three fully developed seeds per NIS (Plate 10a)
black form nov.	Black/deep purple shell colour

FIELD DESCRIPTION

Tree (Plate 7b)

Height 14 (–22) m (average figure followed by maximum in parentheses); dbh 63 (–99) cm; bole smooth, white-grey 5–15 m, occasionally with equal plank like branched buttresses, slash produces abundent turpentine-smelling white sticky inflammable oleoresin; crown open, rounded, width 11 (–18) m. Part deciduous.

Stipules (Plate 3b)

n pairs, 5–10 × 6–10 mm (stem 3 mm long), caducous, auricle shaped, margin entire-serrate, irregularly lobed, inserted on raised flattened base of petiole 2–10 mm from the conjunction of the petiole and branch (or on conjunction of infloresence and branch), twin linear scars visible on branch/petiole after stipules have fallen off.

Leaves

Imparipinate; 3 (2–4) pairs of leaflets (base pair often reduced), plus one terminal. Petiole 6–10 cm flattened at base, carrying stipules 0.2–1.0 cm from base, if stipules missing (common) twin raised scars; petiolules 1–3 cm. Leaflets ovate-lanceolate (sometimes elliptic) 10–30 × 5–15 cm, subcaducous at fruit maturity; margin entire-undulate; base subcordate (sometimes with unequal sides); apex (sub)acuminate (acumen 1.5–2.0 cm recurved); nerves 8–13 pairs.

Inflorescence

Axillary and pseudoterminal (composte) raceme, 6–30 cm long; racemose, older lower flowers opening first; flowers open in early morning, anthers dehisce for 1–4 hours; 10–30 buds/flowers per inflorescence, non-persistent; 1–3 (seldom more) fruits per inflorescence. Polygamodioecious. The ratio of hermaphrodite (h.) to male (m.) or female (f.) flowers differing between inflorescences and trees and over time. Hermaphrodite flowers generally appearing first. Peduncle 3–5 mm diameter.

Flowers (Plate 4)

Buds, m. and h. often in pairs the second bud smaller undeveloped indeterminate; f. single bud, well developed.Pedicel 1–2 cm, tomentose, brown. Calyx densely tomentose.

Sepals 3, green. Petals 3, pale yellow, f. longer than h. and m. Stamens 6, free, m. all same length, f. and h. 3 of 6 20% shorter; anthers m. 1.5–1.8 mm, f. <1.0 mm, h. 1.5–1.8 mm. Disk: f. dull yellow, margin linear; h. bright yellow, margin faintly lobed. Pistil, m. undeveloped rudimental, f. 3–6 mm, h. 3–5 mm; stigma f. glaborous faintly 3 lobed, h. glaborous strongly lobed.

Fruit (Plate 1b)

A drupe. Oval-drop shaped often with 1 (–2) longitudinal grooves/ribs on underside and/or upperside, tapering towards hilum end, without calyx (which stays on end of pedicel); micropyle blunt; 66 (–90) × 40 (–52) × 112 (–140) mm (length × width × circumference); fresh weight 41.2 (–55.0) g. Skin deep purple to black when mature, green immature. Mesocarp yellow sometimes with red anthocyanin pigment colouration, in some cultivars edible (but astringent), rotting away after fruit fall or drying to form tight wrinkled skin, upto 5 mm thick when fresh, moisture content at maturity 70–80%.

Nut-in-shell (NIS) (Plate 9b)

Ellipsoid-oval shaped, tapering towards hilum end (hilum 0.5–1.0 mm diam.), micropyle end with sharp angular edges; cross section 2 or 3 sided, rounded edges, total (or near total) reduction of the sterile cells except in (rare) cultivars/NIS with more than one kernel per NIS; 61 (45–80) × 33 (25–40) × 112 (65–110) mm; weight 15.4 (12.0–20.9) g (<5% m.c.); shell thickness 3.4 mm (2.8–4.0) mm, moisture content at maturity 3–15%.

1 sometimes 2, very rarely 3, kernels (seeds) per NIS.

Shell (endocarp) in 3 bonded layers (Figure 10b): outer, very hard, lignified wall, woody brown, sometimes with purple anthocyanin pigment colouration; inner (axial), less hard, blotched-white; and inner cell wall, brittle, polished brown.

Kernel-in-testa (KIT)

Ovate with longitudenal grooves, edible, non-endospermic seed with 2 intimately entwined cotyledons enclosed in protective testa; 42 (–55) × 25(–30) × 60 (–72) mm; dry weight 3.9 (–5.7) g (<1% m.c.).

Testa in 2 tighty fused parts: outer layer leathery, white when immature, usually brown-mottled red with black veins when mature; inner layer thin transparent airtight (?) membrane. Twin rounded vascular scars after removal from shell.

Kernel oil, edible, fragrant; total oil content 73.6%: saturated 47.9% (palmitic 36.6%, stearic 10.7%, arachidic 0.3%, myristic 0.1%, heptadecanoic 0.1%); monosaturated 27.2% (oleic 26.3%, palmitoleic 0.7%, eicosenoic 0.1%); polyunsaturated 24.8% (linoleic 24.5%, linolenic 0.3%).

Seedling

Germination is epigeous and takes from 5 to 120 days. The shell lid (valve) is slowly forced open at the micropyle end first by pressure from the developing radicle (primary root). The hypocotyl then emerges and quickly pulls the cotyledons (and shell if still attached) clear of the surface. The hypocotyl quickly straightens out and the two green, non-photosynthetic cotyledons flatten out. Cotyledons 2, palmate, 3 lobes (once with 5 (Plate 10b)), green, edible (taste like unripe avocardo), non-photosynthetic, falling off after first true leaf emergence. The first true leaves emerge quickly from a short epicotyl, and the cotyledons soon fall off. The primary (tap) root grows rapidly downwards before lateral roots develop. Hypocotyl emergence to first true leaf emergence takes from 1 to 3 days. First true leaves, opposite, brown turning green.

Uses

The kernels are an important food crop in the Santa Cruz Islands. When fresh, fruits or NIS are hammered open using a stone and the testa removed by hand before the kernel is eaten. Alternatively, kernels or NIS are preserved by slow and continuous drying over kitchen fires enabling the kernels to remain edible for up to 12 months.

The kernels are also inflammable and are reported to have once been used as a primitive candle. A thin reed was inserted in to the kernel as a wick.

The shells are inflammable (with a calorific value of 20 Mj Kg and bulk density of 460 Kg/m^3) and are occasionally used as a cooking fuel.

The timber can be used for canoe construction and custom bowls, and is a good fire wood.

The oleoresin is occasionally used as lighting oil and incense.

The trees frequently form the middle canopy of multi-story food-garden systems.

APPENDIX 3

LIST OF DETERMINATIONS MADE BY BARRY EVANS

A list of all determinations made by the author at various herbaria is shown to assist taxonomists keep track of common misidentifications with the edible SI species of *Canarium, Terminalia* and *Barringtonia.*

Most *Canarium* specimens in the list have been collected and misidentified after Pieter Leenhouts had completed his revision of the genus (Leenhouts 1955, 1956 and 1959).

The frequency of misidentification, e.g. *Canarium salomonense* Burtt. ssp. *salomonense* for *C. harveyi* Seem is indicative of poor mislabelled specimens, the close relationship of some of the species and an over reliance on vernaculars.

Note: Herbaria abbreviations underlined in the Duplicate column in the Table beginning page 80 have been seen and relabelled by the author. Where appropriate, the main criteria for the author's determination is shown in the Comments column.

HERB	REF	COLL DATE	COLLECTOR	LOCATION	OLD NAME	FAMILY	DETERMINATION	DATE	DUPLICATE	COMMENTS
BISH	NGF16787	9/4/64	Henty, E.E.	Bot. Gdn., Lae	*C. salomonense* Burtt. ssp. papuanum Leenh.	BURSE	*C. kaniense* var. *globigerum* Leenh.	6/91	Canb/L/A/ K/BRI/ Bog/Sing/Syd/ UH/PNH/US/ Lae	from Hoogland 3844 type for CANSAL ssp. pap in Leenh. p355
BISH	609	16/3/58	Barrau, J.	Guadalcanal	*Barringtonia* sp.?	LECYT	*B. novae-hiberniae* Laut	6/91		
BISH	610	16/3/58	Barrau, J.	Guadalcanal	*Barringtonia* sp.?	LECYT	*B. procera* (Miers) Knuth	6/91		
BSIP	BSIP18877	20/1/70	Gafui, I.	Choiseul	*C. indicum* L.	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	4/91	K/L	'Adoa'=CANSAL, stipules
BSIP	BSIP19779	1/7/71	Yen, D.E.	Santa Cruz	*C. indicum* L.	BURSE	*C. harveyi* Seem. var. *nova-hebridiense* Leenh.	4/91	BISH/NY	stipules, fl, lvs. checked at BISH
BSIP	BSIP3044	18/2/64	Whitmore, T.C.	Gizo Is.	Canarium	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	4/91	L/K	stipules
BSIP	BSIP3320	19/11/63	Lipaqeto, Z.	N.E. Guadalcanal	c.f. Canarium	BURSE	*C. harveyi* Seem. var. *sapidum* (Hems.) Leenh.	4/91	L/K	'Mala Adoa'<>CANSAL, stipules
BSIP	BSIP6941	26/10/66	Burn-Murdoch, N	S.E. New Georgia	Haplobus sp.	BURSE	*C. harveyi* Seem.	4/91	Lae	has stipules
BSIP	BSIP7415	16/11/66	Burn-Murdoch, N	Isabel	*C. salomonensis* Burtt.	BURSE	*C. harveyi* Seem.	4/91	Lae/L	'Mala Adoa'<>CANSAL, stipules
BSIP	BSIP7830	7/10/66	Beers, W.	Isabel	*C. salomonense* Burtt.	BURSE	*C. harveyi* Seem.	4/91	Lae/L	'Mala Adoa'<>CANSAL, stipules
BSIP	DCRS 551	21/4/88	Henderson, C.P.		*C. indicum* L.	BURSE	*C. harveyi* Seem. var. *nova-hebridiense* Leenh.	4/91	K	stipules, fr
BSIP	DCRS 30?	14/3/88	Henderson, C.P.	BSIP	*T. solomensis* Exell	COMBR	*T. megalocarpa* Exell	4/91	K	fr
BSIP	BSIP12277	23/10/68	Mauriasi, R.	S.W. Guadalcanal	*B. edulis* Seem.	LECYT	*B. novae-hiberniae* Laut	4/91	K?/L	open calyx, edible fr.
BSIP	BSIP12360	1/11/68	Fa'arodo, H.		*B. edulis* Seem.	LECYT	*B. novae-hiberniae* Laut	4/91	K?/L	open calyx, edible fr.
BSIP	BSIP19841	9/4/72	Powell, J.M.		*B. edulis* Seem.	LECYT	*B. procera* (Miers) Knuth	4/91	BISH/CANB/ UPNG	sessile fl. + l., 8-gonous fr.
BSIP	DCRS 293	7/4/88	Henderson, C.P.		B. ararorchasis Merr. and Per.	LECYT	*B. niedenzuana* (K.Sch) Knuth	4/91	K	syn.
BSIP	DCRS 492	1/1/88	Henderson, C.P.		*Barringtonia* sp.	LECYT	*B. niedenzuana* (K.Sch) Knuth	4/91	K	
K	BSIP11315	9/8/68	Kotali, C.	S. Vella	Canarium	BURSE	*C. harveyi* Seem. var. *sapidum* (Hems.) Leenh.	2/90	BSIP/L	
K	BSIP12143	11/10/68	Fa'arodo, H.	S.W. Guadalcanal	Canarium	BURSE	*C. harveyi* Seem.	9/91	BSIP/L	Mala'Adoa
K	BSIP13883	12/4/69	Mauriasi, R.		*C. vitiense* A.Gray	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP/L/LAE	
K	BSIP14026	19/4/69	Mauriasi, R.		Canarium	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP/L	
K	BSIP14407	10/6/69	Mauriasi, R.		Canarium	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP/L	

K	BSIP14526	20/6/69	Mauriasi, R.		Canarium	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP/L	
K	BSIP15699	28/6/69	Mauriasi, R.		Canarium	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP/L	
K	BSIP18936	3/2/70	Gafui, I.		*C. indicum* L.	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP	
K	BSIP3115	20/3/64	Whitmore, T.C.	N.W. New Georgia	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.?	9/91	BSIP/L	
K	BSIP5219	28/2/64	Whitmore, T.C.	S.E. Choiseul	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.	9/91	BSIP/L/LAE	large stipules
K	BSIP5292	6/3/64	Whitmore, T.C.	E. Choiseul	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.?	9/91	BSIP/L	
K	BSIP5299	9/3/64	Whitmore, T.C.	Rob Roy Is, Choiseul	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.	9/91	BSIP/L	
K	BSIP6738	26/1/66	Beers, W.		Canarium	BURSE	*C. indicum* L. var. *indicum*	9/91	BSIP/L	
K	BSIP9055	1/4/68	Gafui, I.	W. Guadalcanal	*C. harveyi* Seem.	BURSE	*C. harveyi* Seem. var. *sapidum* (Hems.) Leenh.	2/90	BSIP/L	
K	BSIP9428	14/5/68	Gatui, I.		Canarium	BURSE	*C. salomonense* Burtt. ssp. *salomonense*	2/90	BSIP/L	
L	BSIP16044	23/8/69	Mauriasi, R.	Isabel	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.	9/91	BSIP	
L	BSIP17539	21/10/69	Gatui, I.	N. Choiseul	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.	9/91	BSIP	
L	BSIP4730	9/9/64	Cowmeadow, A.	N.W. New Georgia	*C. salomonense* Burtt. ssp. *salomonense*	BURSE	*C. harveyi* Seem.?	9/91	BSIP	
SUVA	DA1561	23/5/39	Naitasiri	Nasinu Exp. Sta.	*C. vulgare* Leenh.	BURSE	*C. indicum* L.	5/91		stipules [det. Smith 1969 as CANVUL]
SUVA	DA20809	1/5/78	Sunderason	Naitauba Is.	*C. vulgare* Leenh.	BURSE	*C. indicum* L.	5/91		stipules
SUVA	K281	23/7/64	Nasoni, T.		*C. harveyi* Seem. var. *harveyi*	BURSE	*C. vitiense* A. Gray	5/91		
BRI	LAE60148	30/9/73	Foreman, D. and Vinas, A.	Boridi Village, Central District	C. c.f. *indicum* var. indicum	BURSE	*C. indicum* L. var. *indicum*	2/93	A/L/K/Syd/ Lae/Canb	n.b. alt.1250m
BRI	NGF33259	14/2/72	Leach, G.	Lae Bot. Gdns.	C. *indicum* var. *indicum*	BURSE	*C. vulgare* Leenh.	2/93	L/Canb	entire stipules
SYD	762	1/1/31	Waterhouse, J.	Solomon Islands	Canarium	BURSE	*C. indicum* L. var. *indicum*	3/93		
SYD	NGF35705	14/7/67	Kairo, A. and Streimann, H.	Garagos subdistrict, Lae	Canarium	BURSE	*C. kaniense* var. *globigerum* Leenh.	3/93	QRS	stipules + fr "Dokoro" (Middle Waria)
K	3727	23/8/53	Hoogland, R.D.	3km N of Divinikoari village, N. iv, Papua	*C. kaniense* Laut	BURSE	*C. kaniense* var. *globigerum* Leenh.	1/94		stipules
K	33	27/3/73	Soehoed Sosrodihardjo	Mt Cycloop, Jayapura, Irian Jaya	Canarium	BURSE	*C. indicum* L. var. *indicum*	1/94	L/K/BRI	stipules
QRS	Fletcher Herb. 8053	21/3/43		Karkar Is., PNG	*C. polyphyllum* K. Schuman	BURSE	*C. indicum* L. var. *indicum*	6/94		QRS025093
QRS	LAE 59302	5/11/74			Canarium	BURSE	*C. lamii* Leenh.	6/94		QRS025080

APPENDIX 4

AVERAGE WEIGHT COMPOSITION OF FRESH *CANARIUM* FRUITS IN SOLOMON ISLANDS

	C. indicum[1]		*C. harveyi*[2]		*C. salomonense*[3]	
FRUIT PART	(g)	(%)	(g)	(%)	(g)	(%)
WHOLE FRUIT	33.2	100	41.2	100	12.5	100
FLESH[4]	20.6	62	24.9	60	7.5	60
NUT-IN-SHELL	12.6	38	16.3	40	5.0	40
SHELL[5]	9.8	30	10.7	26	3.7	30
KERNEL-IN-TESTA[6]	2.9	9	5.6	14	1.3	10
(DRY KERNEL-IN-TESTA)[7]	2.0	6	3.9	9	0.9	7

Notes:
Sample size (n) = minimum of 10 fruits × minimum of 10 forms
1. var. *indicum*
2. var. *nova-hebridiense*
3. ssp. *salomonense*
4. 70–80% m.c.
5. 3–15% m.c.
6. 25–40% m.c.
7. <5% m.c., see table 11 for details