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Silvics and wood properties of the common timber tree species on Kolombangara

by
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T.C. Whitmore



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Abstract

Natural forest management in the Solomon Islands is at an important stage of development. Undisturbed forest below the altitudinal limit for logging has mostly been logged at least once, and the remaining unlogged area is under concession. It is therefore inevitable that the focus of forest management will shift from exploitation of pristine forest to management of the large area of logged forest over the next few years. However, the research on which management prescriptions for Solomon Islands forests would be based has only just started, and there is an urgent need for the kind of information required to design appropriate management systems.

This Manual collates the published and unpublished information currently available on the silvicultural behaviour and wood properties of the 12 most common timber tree species in Solomon Islands natural forests. Most of the silvics information has been obtained from a recent analysis of data obtained during monitoring of populations of all trees of these species >4.9cm diameter on permanent sample plots on Kolombangara, as part of the Kolombangara Ecological Survey (KES). The KES has been a research project of the Solomon Islands Forest Department since 1964 and the plots have been monitored 15 times over the 30 year interval. The total area of permanent sample plots was 13.9ha in the early phases of the project but has declined over time as plots have been lost to cyclone damage and logging, although nine plots (5.7ha) have been monitored over the full 30 years of the study.

The silvics data presented include accounts of species distribution and the ecology and demography of seedlings drawn from previous phases of the KES. The Manual also presents updates of tree growth and mortality rates under natural forest conditions, new data on changes in median and maximum crown exposure with tree size, and population responses to cyclones. Sections on plantation experience and wood properties are included, drawn from other published sources.

Thus this Manual brings together in one place a summary of the accumulated knowledge on the twelve species described, which are the main timber-producing species of the Western Solomons. It is hoped that a single reference source will be of value for planning natural forest management. Fuller details on methodology and analysis are not given here but can be found in the source documents on which this Manual is based.

Section 1

Site Description and Methods

Introduction

In this Manual we present a summary of information on the status and behaviour of twelve common tree species on Kolombangara Island in the Western Province of the Solomon Islands. The data has been collected during the 30-year operation of the Kolombangara Ecological Survey (KES), initiated by one of us (T.C.W.) in 1964 and maintained since then as a research project of the Solomon Islands Forest Division (Whitmore 1974, Whitmore & Chaplin 1987). This survey started with 22 sample plots of 0.63ha each. Plots were lost by logging and cyclone damage until in 1986 only 12 remained. Since then nine have continued to be measured, four at Shoulder Hill inland from Poitete and five at Merusu Cove, inland from Iriri village.

The rationale for presenting this information is that the Solomon Islands lacks data on long-term tree growth and mortality to act as a guide to natural forest management. KES is limited because the plots all lie in unlogged natural forest so all information on the long-term growth and dynamics of species is for trees in unmanaged natural forest. However, until data from permanent sample plots in logged forest become available it will be important to make use of the information provided by KES as a first step to the development of a silvicultural system for natural forest management in the Solomon Islands. In the first section we present a description of the study site, a brief history of the project and an outline of the analyses made; in the second section we present the detailed information for each species.

In the Solomons standard abbreviations of tree names are widely used and understood and are therefore used for the names of the twelve species in this Manual.

Site description

The Kolombangara Ecological Survey (KES) is based on a series of permanent sample plots located in tropical evergreen rain forest on Kolombangara in the Western Province (157° E, 8° S). Kolombangara is almost circular in outline (Fig. 1) and was created by volcanic activity in the Pleistocene period. The island rises from sea level to a maximum altitude above sea level of 1420–1580m at the rim of the extinct crater in the centre of the island. Most of Kolombangara is composed of olivine breccias and, although the subsidiary cones on the Beacon Hills in the south-west are of intrusive hornblende andesite (Anon. 1984). On the coastal fringes is a belt of raised limestone reefs or alluvium. None of the sample plots were located on either the hornblende andesite of the Beacon Hills area or the coastal sedimentary deposits.

The soils of the lowlands below 300m overlying Pleistocene breccias and lavas have been studied by van Baren (1961), Lee (1969), Hansell & Wall (1975) and Whitmore (unpublished). The top soils are strongly acidic, although there is wide variation in the values obtained. Lee (1969) found the soils of two forest sites to possess a $\text{pH}_{\text{H}_2\text{O}}$ of 3.5 (at 0–10 and 0–25cm depth). The mean $\text{pH}_{\text{H}_2\text{O}}$ found by Whitmore (unpublished) for 24 topsoil samples (mostly in the range 0–31cm depth) taken from the 22 forest plots described in this paper was 4.6 (range 4.1–5.3). Differences in total N concentration were also apparent between the two studies, the one value obtained by Lee (0.7mg g^{-1} at 0–25cm) being considerably lower than the mean of 4.6mg g^{-1} (range 1.5–15.5 mg g^{-1} for samples in the range 0–31cm depth) obtained for the 24 profiles studied by Whitmore (unpublished). The total P concentration was studied only by Lee (1969) and proved to be very high (0.5 and 0.6mg g^{-1} at 0–10 and 0–25cm respectively for different profiles), but 'available' P (extracted using Truog's reagent) was recorded as zero by van Baren (1961). Full chemical analyses of soils are presented in Table 1. All studies lead to the conclusion that the concentrations of exchangeable cations is low as a result of excessive leaching over long periods. Soil characteristics change with altitude, particularly in

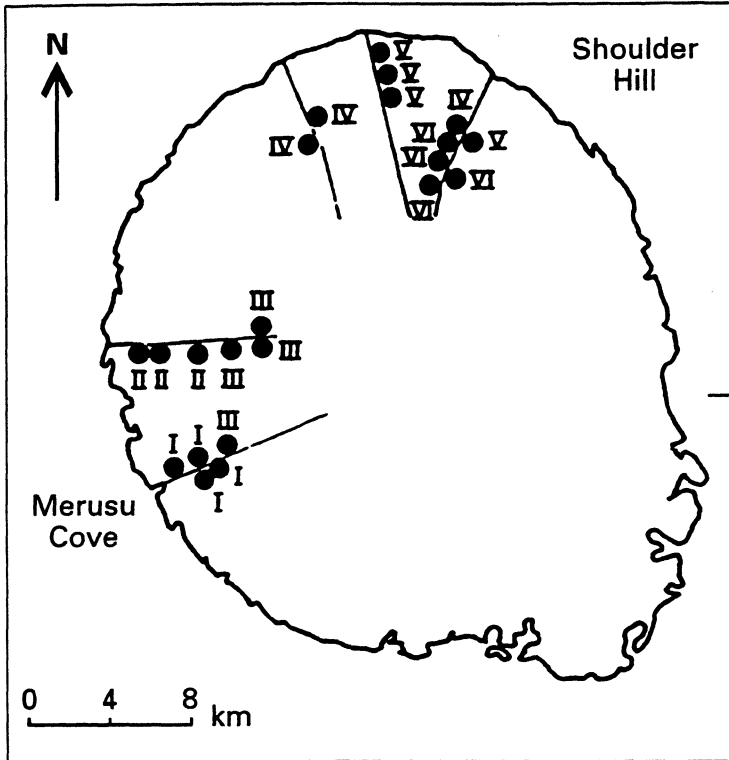


Figure 1

Kolombangara showing location of plots and forest types of the Kolombangara Ecological Survey (after Whitmore 1974)

relation to humus type and related properties (Lee 1969); the foregoing comments apply to the lowland forest belt lying below 305m a.s.l. Relationships between species and soil are discussed in Greig-Smith *et al.* (1967), Lee (1969) and Whitmore (1974).

Kolombangara has a wet equatorial climate with a typical tropical diurnal temperature cycle. Long-term rainfall data is available from Mounga (January 1965– December 1970), Vanga (January 1971–present) and Kukundu (January 1965–November 1967) on the west coast, and from Poitete (December 1976–present) on the north coast. Mounga and Vanga probably represent the same rainfall station (Neumann 1986), in which case mean annual rainfall over the interval 1965–1993 was 3196mm (range 2571–4012mm). On the west coast the driest month was June (mean 173mm) and the wettest was February (mean 395mm). At Poitete on the north coast mean annual rainfall was 3106mm for the 11 years of complete records (1981, 1983, 1985–1993) at station L39 and 2957mm for the 10 years of complete records (1983, 1985–1993) at station L44, suggesting that these sites had a similar rainfall regime to the west coast. Over the same intervals the driest month August at L39 (mean 173mm) and September at L44 (mean 165mm), but in both cases the wettest month was March (means of 370 and 400mm respectively). These data were all taken from coastal stations and it is highly likely that rainfall increases inland and with altitude (Brookfield 1969). Temperature records are not available, but in nearby Munda, New Georgia Island, mean daily temperature varied between 23.4°C (August) and 26.1°C (December) over the period 1962–1985 (Neumann 1986).

Table 1.

Soil characteristics of the twenty-two plots on Kolombangara, Solomon Islands

Plot	Location		Depth (cm)	M.C.* (%)	L.O.I. [†] (%)	Organic C (%)	Total N (mg g ⁻¹)	C:N ratio	pH (H ₂ O) [‡]	pH (CaCl ₂) [‡]
1	Sandfly	a	0-15	4.1	18.3	2.5	2.4	10	4.4	3.8
		b	15-31	3.7	16.0	1.2	1.2	10	4.8	4.0
2	Sandfly	a	3-13	7.3	33.5	11.1	6.8	16	4.7	3.9
		b	13-25	5.3	22.2	2.8	2.1	13	4.6	4.1
3	Sandfly	a	0-25	2.6	23.0	1.9	1.9	10	4.9	4.4
		b	25-51	2.3	22.0	0.9	0.7	13	5.1	4.6
4	Sandfly	a	5-25	3.8	21.8	2.2	1.8	12	4.6	3.9
		b	31-51	3.8	19.8	1.1	0.9	12	4.6	4.0
5A	Merusu	a	0-23	5.1	20.2	3.4	2.9	12	4.7	4.0
		b	23-46	4.5	16.3	1.0	1.2	8	4.6	4.1
5B	Merusu	a	0-23	4.8	20.2	3.1	2.5	12	4.6	3.9
		b	31-51	4.4	16.8	0.9	0.9	10	4.7	4.1
6	Merusu	a	0-15	3.8	23.7	2.6	1.9	14	4.6	4.0
		b	25-51	3.3	21.2	0.9	0.9	10	4.6	4.1
7	Merusu	a	0-15	5.0	23.8	5.1	3.8	13	4.3	3.7
		b	23-61	4.0	17.9	1.2	1.0	12	4.6	4.0
8	Merusu	a	0-10	8.5	59.1	23.8	15.5	15	4.3	3.0
		b	15-76	2.6	26.6	1.1	0.9	12	4.7	4.3
9	Merusu	a	5-51	3.7	23.8	1.6	13.7	12	5.3	4.6
		b	61-76	3.2	21.0	0.5	0.3	17	4.9	4.8
10	Shoulder	a	0-23	3.6	18.5	3.3	3.3	10	5.1	4.2
		b	31-53	3.1	16.4	1.0	1.1	9	5.0	4.4
11	Shoulder	a	0-23	5.7	20.5	3.8	4.3	9	4.8	4.1
		b	23-46	5.3	16.5	1.4	1.3	11	4.7	4.2
12	Shoulder	a	0-23	6.8	26.2	5.9	4.6	13	4.5	3.7
		b	23-61	5.0	18.7	1.3	1.5	9	4.3	4.0
13	Shoulder	a	0-23	6.0	23.8	4.2	3.2	13	4.8	4.0
		b	31-51	4.4	18.6	1.1	1.0	11	4.8	4.1
14	Shoulder	a	5-31	5.1	22.5	4.2	2.3	18	4.5	3.9
		b	43-63	4.6	14.5	1.8	1.3	14	4.5	3.9
15A	Shoulder	a	0-25	6.1	25.3	4.3	3.5	12	4.6	3.8
		b	25-51	5.2	22.5	2.3	1.9	12	4.5	3.9
15B	Shoulder	a	0-51	6.4	26.2	4.0	3.7	11	4.5	3.9
		b	51-76	5.7	20.5	1.4	1.0	14	4.6	4.0
16	Lodomae	a	0-31	5.1	17.9	2.5	3.0	8	4.8	4.3
		b	31-51	4.8	15.3	1.0	1.2	8	4.6	4.2
		c	51-76	5.0	14.9	0.6	1.0	6	4.6	4.2
17	Lodomae	a	0-23	5.5	20.1	3.8	3.9	10	4.7	4.2
		b	25-51	5.3	16.0	1.1	1.4	8	4.5	4.1
18	Lodomae	a	8-31	4.2	20.5	3.5	3.6	10	4.6	4.2
		b	31-56	3.6	16.0	0.8	0.8	10	4.9	4.5
		c	56-81	3.5	14.8	1.2	1.2	10	5.0	4.5
19	Rei	a	0-51	6.3	20.7	4.3	3.2	13	4.6	3.9
		b	61-86	6.5	15.6	1.1	0.9	12	4.4	4.0
20	Rei	a	0-23	5.1	17.0	2.7	2.5	11	4.5	3.9
		b	31-51	4.7	15.5	1.0	1.2	8	4.5	4.0
21	Sandfly	a	0-31	4.1	16.2	1.9	2.4	8	4.7	4.1
		b	36-61	3.9	14.5	0.7	0.9	8	4.7	4.1
		c	66-91	4.0	14.7	0.5	0.5	10	4.7	4.1
22	Sandfly	a	0-38	4.8	20.1	2.1	1.5	14	4.6	4.1
		b	38-76	4.2	18.3	1.0	0.9	11	4.7	4.2
		c	91-122	3.8	17.4	0.6	0.8	8	4.7	4.2

Table 1. continued

Plot	Location		Exchangeable (m.e.100 g ⁻¹)					Total	C.E.C. ¹ H ²	% m.e. 100 g ⁻¹	saturation
			Ca	Mg	K	Na					
1	Sandfly	a	0.5	0.18	0.13	0.11	0.9	6.3	7.2	13	
		b	0.7	0.18	0.06	0.12	1.1	7.9	9.0	12	
2	Sandfly	a	0.8	0.47	0.26	0.25	1.8	29.7	31.5	6	
		b	0.3	0.15	0.06	0.13	0.6	15.8	16.4	4	
3	Sandfly	a	0.2	0.17	0.05	0.12	0.5	12.0	12.5	4	
		b	0.2	0.10	0.02	0.11	0.4	6.3	6.7	6	
4	Sandfly	a	0.3	0.12	0.06	0.11	0.6	13.0	13.6	4	
		b	0.3	0.07	0.02	0.10	0.5	8.6	9.1	5	
5A	Merusu	a	0.3	0.50	0.12	0.15	1.1	14.1	15.2	7	
		b	0.3	0.20	0.07	0.14	0.7	8.9	9.6	7	
5B	Merusu	a	0.5	0.26	0.09	0.19	1.0	14.8	15.8	6	
		b	0.3	0.13	0.02	0.15	0.6	8.7	9.3	6	
6	Merusu	a	0.2	0.24	0.09	0.15	0.7	11.4	12.1	6	
		b	0.3	0.11	0.06	0.12	0.6	7.1	7.7	8	
7	Merusu	a	0.5	0.55	0.13	0.16	1.3	19.7	21.0	6	
		b	0.3	0.04	0.04	0.16	0.5	8.8	9.3	5	
8	Merusu	a	1.4	2.80	0.79	0.48	5.5	38.5	44.0	13	
		b	0.3	0.08	0.05	0.12	0.6	8.0	8.6	7	
9	Merusu	a	0.5	0.35	0.06	0.12	1.0	9.2	10.2	10	
		b	0.3	0.14	0.23	0.18	0.9	5.6	6.5	14	
10	Shoulder	a	0.8	0.79	0.13	0.13	1.9	13.9	15.8	12	
		b	0.5	0.20	0.15	0.23	1.1	8.2	9.3	12	
11	Shoulder	a	0.3	0.47	0.34	0.22	1.3	14.7	16.0	8	
		b	0.5	0.18	0.05	0.18	0.9	10.1	11.0	8	
12	Shoulder	a	0.8	0.35	0.25	0.18	1.6	10.3	11.9	13	
		b	0.2	0.09	0.06	0.12	0.5	9.9	10.4	5	
13	Shoulder	a	0.5	0.34	0.13	0.18	1.2	19.4	20.6	6	
		b	0.5	0.32	0.06	0.21	1.1	8.4	9.5	12	
14	Shoulder	a	0.3	0.13	0.08	0.14	0.7	23.7	24.4	3	
		b	0.2	0.06	0.05	0.12	0.4	11.4	11.8	3	
15A	Shoulder	a	0.3	0.18	0.16	0.14	0.8	20.7	21.5	4	
		b	0.3	0.12	0.08	0.12	0.6	14.0	14.6	4	
15B	Shoulder	a	0.3	0.24	0.19	0.25	1.0	20.7	21.7	5	
		b	0.3	0.20	0.18	0.20	0.9	11.5	12.4	7	
16	Lodomae	a	0.7	0.26	0.44	0.25	1.7	11.8	13.5	13	
		b	0.3	0.12	0.08	0.20	0.7	9.4	10.1	7	
		c	0.3	0.20	0.14	0.21	0.9	8.5	9.4	10	
17	Lodomae	a	0.7	0.35	0.19	0.14	1.4	15.8	17.2	8	
		b	0.2	0.08	0.04	0.14	0.5	10.0	10.5	5	
18	Lodomae	a	0.3	0.27	0.19	0.14	0.9	16.9	17.8	5	
		b	0.2	0.15	0.05	0.13	0.5	8.8	9.3	5	
		c	0.3	0.15	0.07	0.13	0.7	9.6	10.3	7	
19	Rei	a	0.3	0.23	0.12	0.17	0.8	22.9	23.7	3	
		b	0.2	0.34	0.09	0.20	0.8	11.5	12.3	7	
20	Rei	a	0.5	0.15	0.18	0.24	1.1	15.4	16.5	7	
		b	0.3	0.15	0.10	0.22	0.8	10.2	11.0	7	
21	Sandfly	a	0.23	0.13	0.23	0.90	10.9	11.8	22.7	8	
		b	0.18	0.06	0.19	0.60	7.4	8.0	15.4	8	
		c	0.41	0.07	0.24	1.00	7.5	8.5	16.0	12	
22	Sandfly	a	0.2	0.19	0.06	0.15	0.6	14.3	14.9	4	
		b	0.3	0.34	0.07	0.23	0.9	8.4	9.3	10	
		c	0.2	0.32	0.04	0.18	0.7	7.6	8.3	8	

¹Moisture content; ²Loss on Ignition; ³1:2.5 soil:water; ⁴M/100 CaCl₂; ⁵by addition

Vegetation

Before the onset of logging in the early 1960s most of Kolombangara below about 300m was covered by lowland evergreen tropical rain forest with a coastal fringe of beach vegetation or mangrove forest (Whitmore 1974). Three-quarters of the island was logged by the mid 1980s and converted either to various agricultural uses, including cattle under trees or, by the Forest Division, to forest plantations which included much *Camposperma brevipetiolatum* (CAMB). The plantations are now in the course of being harvested and the whole landscape is being planted, by Kolombangara Forest Products Ltd, mainly with *Gmelina arborea* plus some *Eucalyptus deglupta* and *Swietenia macrophylla*. Natural forest remains above 400m and grades into montane forest with increasing altitude.

The tree flora of Kolombangara contains at least 192 species which reach 30cm girth at 1.3m height (Whitmore 1974). The total number of tree species on the KES plots (0.63ha) varied between 30 and 53, which is low compared to tropical lowland rain forests elsewhere (Whitmore 1974, 1984 Fig. 1.5). The paucity of the Kolombangara tree flora reflects both its status as an island and the geological history of the region (Whitmore 1969). Climbers and epiphytes are abundant (Whitmore 1974).

Floristic analysis

The enumerations of stems >30cm (1 ft) girth conducted in 1964 on all 22 plots were submitted to vegetation analysis by Greig-Smith *et al.* (1967) using a combination of stand classification by association analysis (Williams & Lambert 1959, 1960) followed by ordination by principal components analysis of Orloci's coefficient (Orloci 1966, Austin & Orloci 1966). For this analysis each oblong plot was divided into five linear transverse sub-plots of 0.126ha, yielding a total of 110 stands. The initial classification of stands resulted in a high-level division between a group of mostly west-coast stands containing *Teysmanniodendron ahernianum* and the remaining north-coast stands which lacked this species. Ordination within these groups resulted in the identification of a number of 'misclassified' stands which were transferred to more appropriate groups. The redefined northern and western forest types were then subjected to association analysis. This procedure resulted in the recognition of six floristically distinct forest types among 96 of the 110 stands, the remaining 14 falling into eight small classes. The forest types are numbered I to VI. Their distribution in relation to the 22 plots is shown in Fig. 1 and the abundance of each of the 12 common big tree species in the six forest types is shown in Table 2 (based on Table 2.4 of Whitmore 1974). Further ordination within groups showed changes in floristic composition with altitude, topography and (in one case) history of human-induced disturbance. Notes on the distribution of the twelve common big trees were reported by Greig-Smith *et al.* (1967) and are reproduced below.

Nomenclature follows Stevens (1980) for *Calophyllum*, Prance (1987) for *Parinari* and Whitmore (1966) for all other genera.

Change with time

All trees of the twelve commonest big tree species over 15cm (6in) girth were mapped and measured at rings painted at 1.3m or above buttresses. Crown form and exposure (CEI, crown exposure index) were recorded on the five point scales of Dawkins (1958). These measurements were repeated eight times at approximately six month intervals until 1971. At repeat measurements deaths and recruits were noted.

Table 2.

Mean abundance (stems ha⁻¹ >30cm gbh) of the 12 common big tree species in six different forest types on Kolombangara, Solomon Islands (from Greig-Smith *et al.* 1967, Whitmore 1974)

		Forest Type					
		I	II	III	IV	V	VI
<i>Calophyllum neo-ebudicum</i>	CALN	0.5	2.3	0.8	13.8	3.0	9.0
<i>Calophyllum peekelii</i>	CALP	7.0	8.3	3.0	13.8	8.8	0.0
<i>Camptosperma brevipetiolatum</i>	CAMB	10.3	21.8	15.0	11.3	0.0	4.5
<i>Dillenia salomonensis</i>	DILS	30.0	6.8	8.3	0.0	0.0	0.0
<i>Elaeocarpus sphaericus</i>	ELASP	0.0	0.5	0.0	7.5	2.3	0.8
<i>Endospermum medullosum</i>	ENDM	0.0	0.5	0.0	2.3	5.8	5.3
<i>Gmelina moluccana</i>	GMEM	2.3	0.5	2.0	4.5	1.0	4.5
<i>Maranthes corymbosa</i>	MARC	0.0	3.3	0.5	6.0	1.3	1.3
<i>Parinari papuana</i>	PARP	7.0	11.3	4.3	9.0	9.8	5.8
<i>Pometia pinnata</i>	POMP	0.5	0.0	0.0	4.5	2.8	2.5
<i>Schizomeria serrata</i>	SCHS	2.3	1.0	3.8	4.5	0.5	6.5
<i>Terminalia calamansanai</i>	TERCAL	0.0	3.3	0.5	6.0	12.3	16.0

Table 3.

The four species groups among the 12 common timber tree species classified according to the conditions required for seedling establishment and onward growth, and their pioneer index. Based on observations over 6.6 years 1964-1971 (Whitmore 1974, Table 7.6; 1989, Table 1).

Pioneer index	Species		Conditions to establish	Conditions to grow up
1	<i>Dillenia salomonensis</i>	DILS	High forest	High forest
	<i>Maranthes corymbosa</i>	MARC	High forest	High forest
	<i>Parinari papuana</i>	PARP	High forest	High forest
	<i>Schizomeria serrata</i>	SCHS	High forest	High forest
2	<i>Calophyllum neo-ebudicum</i>	CALN	High forest/small gaps	High forest/gaps
	<i>Calophyllum peekelii</i>	CALP	High forest	High forest/gaps
	<i>Pometia pinnata</i>	POMP	High forest/ disturbed	High forest/?small gaps
3	<i>Camptosperma brevipetiolatum</i>	CAMB	High forest/ gaps	Gaps
	<i>Elaeocarpus sphaericus</i>	ELASP	High forest	Gaps
4	<i>Endospermum medullosum</i>	ENDM	Mostly gaps	Gaps
	<i>Gmelina moluccana</i>	GMEM	Mostly gaps	Gaps
	<i>Terminalia calamansanai</i>	TERCAL	High forest, soon dying except in gaps	Gaps

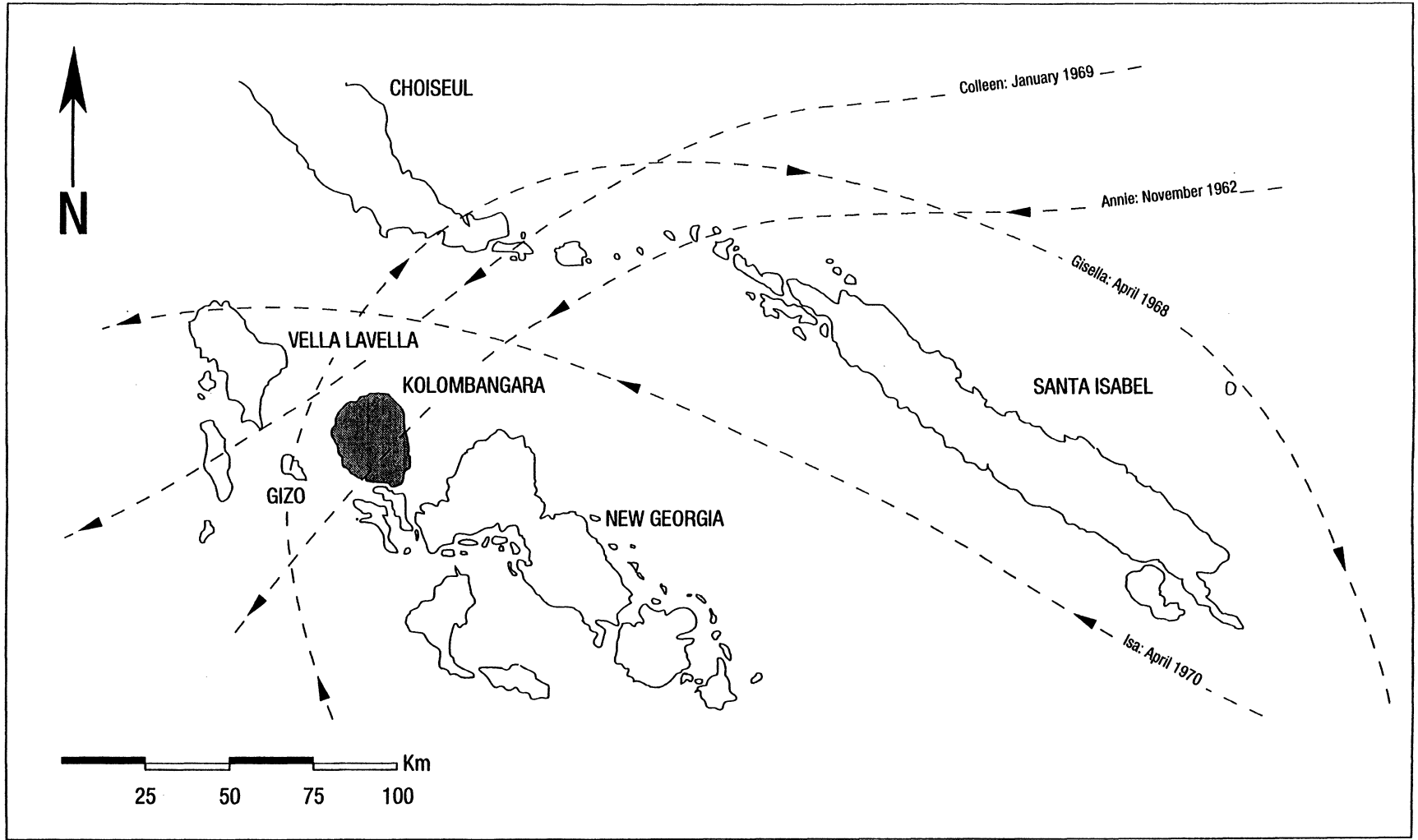


Figure 2
Cyclones that have passed over or close to Kolombangara 1964–1994

The state of the forest canopy was recorded subplot by subplot four times, between August 1966 and March 1971. During this period several cyclones passed over or near to Kolombangara, Fig. 2. Cyclone Annie crossed the island in November 1967, 3.3 years after the KES started. One plot, xviii, was lost. Meteorological records now show three further cyclones then passed near Kolombangara, Gisela (April 1968), Colleen (January 1969) and Isa (April 1970). Their exact paths are not known. The canopy records suggest Isa caused considerable damage but damage caused by Gisela cannot in general be distinguished in the records from that known to have been caused by Annie. Colleen seems not to have caused any damage.

Analysis of the first nine sets of measurements, up to March 1971 (6.6 years) were published as Whitmore (1974). This analysis encompassed two distinct episodes of cyclone-induced canopy damage due to Annie plus Gisela and then Isa, though they were not treated separately because only Annie had been noted. Plots were then progressively lost by logging. Measurements on those that persisted were made at 4.5, 3.5 and 5.1 year intervals. At the twelfth set canopy state was again recorded. After the twelfth set, in November 1985, at 21.3 years, a second analysis was made of the twelve remaining plots (Whitmore 1989). There had been no major canopy damage since March 1971, and indeed no cyclones are known to have passed across or near Kolombangara during that 14.9 year time interval.

A decision was made to reduce the survey to the nine plots at Merusu Cove and Shoulder Hill (Whitmore & Chaplin 1987) and these were remeasured at 3.4, 2.2 and 2.6 year intervals, up to 29.5 years at January 1994 after which a further analysis was made. Again no cyclone damage was found (Burslem *et al.* in prep.).

The full details of the three sets of analyses are presented elsewhere (Whitmore 1974, 1989, Burslem *et al.* in prep.). The objective of this Forest Record is to present the most important findings on the growth of the twelve common big tree species in the unlogged forests of Kolombangara, as a guide to their probable performance in logged forest for which there is as yet no data.

Regeneration behaviour

All plants less than 15cm girth of these 12 common big tree species were recorded by height class per 20 x 20m subplot five times over the first 6.6 years, together with two different ratings of canopy openness over each subplot.

Analysis at 6.6 years showed major differences between the twelve species in the canopy conditions favoured, firstly for seedlings to establish and, secondly, for them to grow up and persist, Table 3. At one extreme a group of four species was observed to both establish and grow up under the closed canopy of high forest. At the other extreme three species required gaps for both establishment and release. The other five species fell into two intermediate groups. The two extreme groups are respectively shade-tolerant climax and light-demanding pioneer species (*sensu* Swaine & Whitmore 1988), at least as far as their observed seedling behaviour. The four groups were assigned a pioneer index on a scale 1 to 4, see Table 3. The mean pioneer index of each plot and forest type and its change through time was discussed in both the 20 and 30 year analyses. The 30 year analyses also showed some change in the rank order of species with increasing girth with respect to crown exposure (*viz* amount of light received) (Burslem & Whitmore in prep.).

Crown exposure, growth rate and mortality rate

For each species these three important aspects of ecology are given both as a short description and as a figure.

Crown exposure is recorded on the scale of 1–5 introduced by Dawkins (1958) where 1 is a completely overtopped crown and 5 is an emergent one. On the figure the individual trees of the KES are shown as well as the mean exposure index for each diameter class.

Diameter growth is important information for silviculture. The figures of growth rate against diameter show both the value for each tree and also a curve which is the best fit regression using a power exponential function, as recommended by Alder (1995). Alder points out that where there are few big trees the growth rate curve has little meaning and can certainly not be extrapolated. This applies especially to the rapidly rising growth rate found by KES for MARC (Fig.10), and to a lesser extent to the curve for CALP (Fig.4). The twelve species have widely different growth rates, for which reason the y axes of these curves are not all the same.

Thirdly, mortality for trees in the different crown exposure classes is shown. This gives an indication of how strongly light-requiring the different species are.

Section 2

Species accounts

1 *Calophyllum neo-ebudicum* Guillaumin

Family: Guttiferae

Common synonym: *Calophyllum vitiense* Turr.

Forest Division abbreviation: CALV (revision to CALN recommended to reflect the name change)

Kwara'ae name: Gwaragwaro

Tree occasionally reaching huge size, 220cm diameter, but usually smaller than *C. peekelii*; bole columnar; crown dense. Well-drained lowland forests throughout.

Distribution

?Moluccas, New Britain, and Bougainville, to Vanuatu, Fiji, Samoa and Tonga (for map see Stevens 1980, p. 549)

Distribution on Kolombangara

On Kolombangara CALN occurs on both north and west coasts, but is most common in northern upland forests (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit is an ovoid or ellipsoid to subspherical blue-black drupe with a leathery flesh and dimensions 2.1–3.7 (–4.3) by 1.5–2.8cm (Stevens 1980, Whitmore 1974).

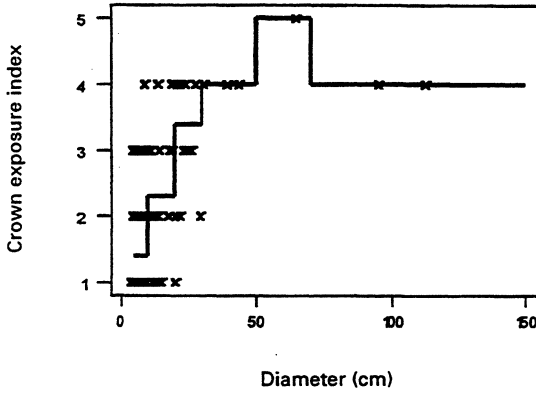
Seedling demography and ecology

Seedling populations are present in small to medium numbers on all plots, even where mature trees were absent. Populations are larger in north coast forests (mostly in the range 48–240 seedlings ha⁻¹) than the west coast forests (7–96 seedlings ha⁻¹). Recruitment occurs in frequent localised flushes, although a large proportion (up to 75%) of seedlings die in the first year. The high mortality rate is countered by the abundant recruitment, which doubles or trebles the seedling population over short periods. Seedlings of CALN *neo-ebudicum* establish in high forest and are able to grow on in either high forest or gaps, resulting in classification as a pioneer index 2 species, along with CALP and POMP (Whitmore 1989).

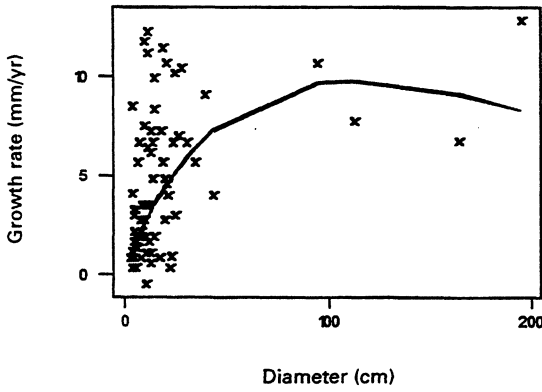
Crown exposure (Fig.3)

Calophyllum neo-ebudicum, with DILS, possessed the lowest median crown exposure index for stems ≤10cm diameter (1.4). However, the rate of increase in crown exposure with tree size is very rapid, such that the median value for stems >20–30cm diameter (3.4) is greater than for all other species apart from ELASP. Sample sizes of stems >30cm diameter are limited, but there is little evidence that CALN becomes emergent. In conclusion there can be no doubt that CALN is strongly shade-tolerant at low size classes, but equally there is evidence that it becomes relatively much less so in the diameter class range >10–50cm.

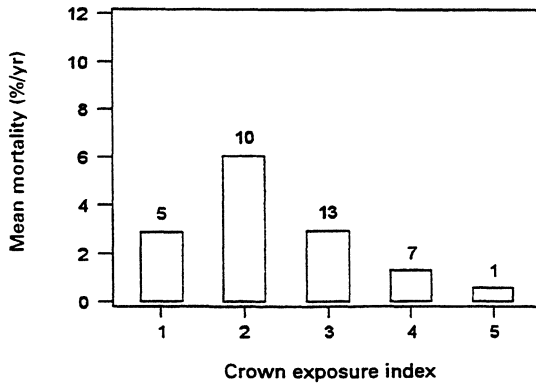
Figure 3 *Calophyllum neo-ebudicum*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964-1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

Diameter growth rates (Fig.3)

Median growth rates increased from 1.9mm yr⁻¹ for stems 10cm diameter to 8.8mm yr⁻¹ among stems of >50–70cm diameter, and then decreased to 8.0mm yr⁻¹ among stems >70cm diameter. Stems >50cm diameter grew faster than all species other than CALP; growth rates of smaller stems were exceeded only by the least shade-tolerant species and tended to be greater than growth rates of CALP. Maximum growth rates were mostly in the range 1.5–2.0cm yr⁻¹, but values of nearly 4.0cm yr⁻¹ were recorded.

Mortality rates (excluding cyclone effects) (Fig.3)

Mean annual mortality rate decreases from 3.1% yr⁻¹ for stems ≤10cm diameter to 2.4% yr⁻¹ for stems >10cm diameter. Mean annual mortality rates show a declining trend with size class for stems >20cm diameter, although the relatively high rates for stems in the range >10–20cm diameter result in a high mean mortality rate for all stems >10cm diameter, exceeded only by CAMB, ELASP and ENDM. For stems ≤30cm diameter mean annual mortality rates were much greater for CALN than for CALP, while for stems >30–100cm diameter the opposite was the case.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 3.8% (3 individuals), a value which was much lower than the mean for all species combined (7%). Recruitment since cyclone Annie has been strongly episodic, with major peaks in the intervals September/October 1975–February/March 1979 (7.2% yr⁻¹), 8–12 years after cyclone Annie, and in June/July 1991–February 1994 (10.5% yr⁻¹), and subsidiary peaks in February 1971–September/October 1975 (2.7% yr⁻¹) and November 1985–April/May 1989 (3.6% yr⁻¹). This pattern presumably reflects the occasional occurrence of favourable conditions for release of seedling flushes. At the 1975 enumeration 2.5% of all new recruits were CALN on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 13.0% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

A number of trial plots have been established (Sandom 1978, Chaplin 1988a), but the species has never been planted on a large scale by the Forest Division. Growth rates of young trees in trial plots are very similar to CALP (Sandom 1978). Data from the KES plots suggest that diameter growth rates of trees ≥50cm diameter are likely to be lower than for CALP, but higher than many other species.

Wood properties

Calophyllum neo-ebudicum is grouped with CALP by Pleydell (1970), as both species produce a log that is usually sound, uniform and free of end splits, and other properties are very similar. Anon. (1976) has reported that CALN has a higher density timber than CALP averaging 500kg m⁻³ for basic density, and that the sapwood is susceptible to *Lyctus* beetle attack. Tests on Fijian logs of CALN suggested lower durability than CALP (Anon. 1976). A complete description of mechanical and physical properties is presented by Anon. (1976). Logs tend to sink though considered floaters (Pleydell 1970).

Utilization

Most logs from natural forests are peeled for veneer production, although the straight-grained timber also lends itself a wide variety of uses from furniture manufacture to construction (Chaplin 1993, Pleydell 1970). In Solomon Islands poles are cut for fishing spears and rafters (Chaplin 1993).

2. *Calophyllum peekelii* Lauterb.

Family: Guttiferae

Common synonym: *Calophyllum kajewskii* A.C. Smith

Forest Division abbreviation: CALK (revision to CALP recommended to reflect the name change).

Kwara'ae name: Ba'ula

Tree reaching huge size, 160cm diameter; bole columnar; crown dense. Lowland forest including coastal swamps and inland ridges.

Distribution

Japen Island; scattered on mainland New Guinea; New Britain and New Ireland to the Solomon Islands (for map see Stevens 1980, p. 586).

Distribution on Kolombangara

On Kolombangara CALP occurs in lowland forest on north and west coasts, but is absent from slopes (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit is a spherical to ovoid blue-black drupe with a leathery flesh which dries to a brownish colour. Stevens (1980) reported the dimensions of the fruit of CALP to be 4.5–7 by 4.2–6cm, but records for Solomon Islands (as *C. kajewskii*) suggest smaller fruits of diameter 2.5–3.7cm (Whitmore 1974). The fruits are dispersed by hornbills and flying foxes, although a large number are not dispersed beyond the crown of the parent tree (Chaplin 1988a). After removal of the fleshy exocarp there are 30–50 dry seed kg⁻¹ (Chaplin 1988a).

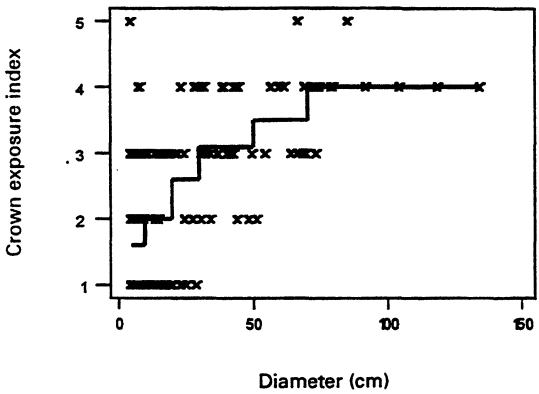
Seedling demography and ecology

The size of natural seedling populations may be very high, varying in the range 720–1000 (-2400) seedlings ha⁻¹. Recruitment of seedlings is frequent, although approximately half of all new recruits die in the first year, resulting in a stable population structure. Seedlings are able to establish and grow under a wide range of canopy conditions (Whitmore 1974), resulting in a pioneer index 2 classification (Whitmore 1989).

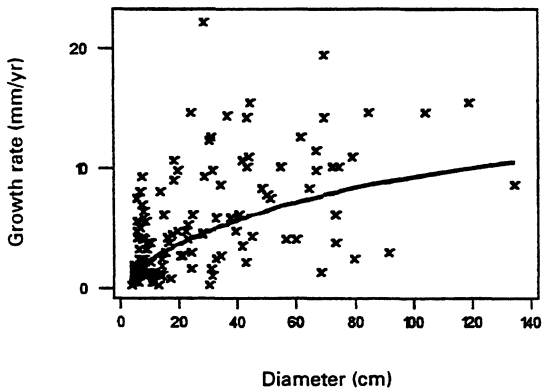
Crown exposure (Fig.4)

Stems of ≤10cm diameter had a median canopy exposure of 1.6, which is lower than similar sized stems of all species except CALN and DILS. Among stems >10–20cm diameter CALP possessed the most strongly shaded stems (median Crown Exposure Index 2.0). Above 20cm diameter canopy exposure of CALP increased consistently with size class, resulting in relatively high indices for stems of diameter >50–70cm (median 3.5) and >70cm (median 4.0). Thus the relative shade tolerance of this species among small stems is not maintained in larger sizes.

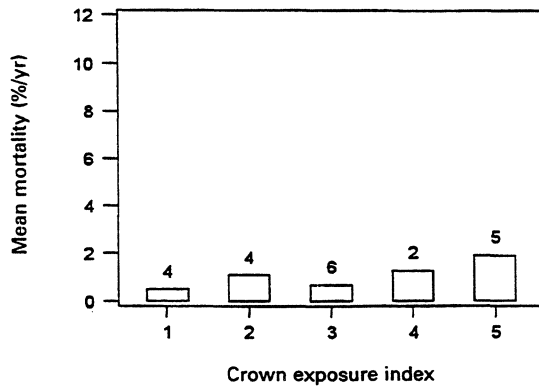
Figure 4 *Calophyllum peekelii*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

Diameter growth rates (Fig.4)

Median growth rates increased with size class, from 1.7mm yr⁻¹ for stems ≤10cm diameter to 10.2mm yr⁻¹ for stems >70cm diameter. CALP and MARC are the only species to show increases in growth rate with size up to the largest individuals. Comparing these growth rates with other species suggests that CALP is not particularly fast-growing at small size classes, but does grow fast as a large tree. Above 50cm diameter CALP had the highest median growth rates of the twelve species studied on Kolombangara. Maximum growth rates were greater than 1.5cm yr⁻¹ in all size classes, and peaked at nearly 3.5cm yr⁻¹.

Mortality rates (excluding cyclone effects) (Fig.4)

Annual mortality rates increase from 0.6% yr⁻¹ among stems ≤10cm diameter to 1.4% yr⁻¹ among stems >10cm diameter. For stems of diameter >10–30cm there is no apparent relation between annual mortality rate and size class, although with increasing size above 30cm diameter there is a marked decrease in annual mortality rate with size class. In most size classes annual mortality rates are low compared to the other species studied, but for stems >30–50cm diameter annual mortality rates of CALP are the highest encountered in the size class.

Response to cyclone

Eight percent of trees (11 individuals) died during the interval spanning cyclone Annie (August 1967–February 1968), a value which is very similar to the mean for all species combined (7%). Recruitment of stems above 4.85cm dbh was only recorded during August 1968–February 1971 (0.3% yr⁻¹) and February 1971–September/October 1975 (2.3% yr⁻¹), i.e. peaking 4–8 years after cyclone Annie. At the 1975 enumeration 14.8% of all new recruits were CALP on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 4.3% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

Calophyllum peekelii is classified by Chaplin (1993) as a minor species with potential as an important plantation species, although it is currently planted only in research trials. The species is considered silviculturally similar to mahogany (*Swietenia macrophylla*), in which case yields of 250–300m³ ha⁻¹ from 150–250 stems ha⁻¹ could be expected on a 30-year rotation (Chaplin 1993). Chaplin (1993) recommends close-line planting of CALP planted at 3 x 3m (1,111 stems ha⁻¹) or 3 x 3m (833 stems ha⁻¹) to ensure site capture within two years. Weeding is required before canopy closure. Two thinning operations of up to 50% achieves the desired final crop stocking of 150–250 stems ha⁻¹. Growth rates in trial plots have been uniform and promising, with 25-year old trees attaining a diameter of about 30cm and a dominant height of about 30m (Chaplin 1993). This perspective conforms with the data from the KES plots, which show CALP to be the fastest-growing of the 12 species among trees ≥50cm diameter.

Wood properties

The log is normally sound and uniform, lacking buttresses or taper and relatively free of defects, knots or end splits (Anon. 1976, Pleydell 1970). Logs from natural forest are not affected by sap-stain fungi or *Lyctus* beetle attack, and pin-hole borer attack is restricted to the damaged sapwood (Anon. 1976). The heartwood is not resistant to termites (Pleydell 1970). A medium-hard timber with basic density 480kg m⁻³ (Anon. 1976)–500kg m⁻³ (Chaplin 1993) and straight grain. Sapwood is pale orange brown and heartwood a red-brown colour similar to mahogany, darkening on exposure (Pleydell 1970). A complete description of mechanical and physical properties is presented by Anon. (1976). Logs tend to sink though considered floaters (Pleydell 1970).

Utilization

Most logs from natural forests are peeled for veneer production, although the straight-grained timber also lends itself to many uses from furniture manufacture to construction (Chaplin 1993, Pleydell 1970). In Solomon Islands poles are cut for fishing spears and rafters (Chaplin 1993).

3. *Camptosperma brevipetiolatum* Volkens

Family: Anacardiaceae

Forest Divison abbreviation: CAMB

Kwara'ae name: Ketekete

Tree commonly to 100cm diameter; bole tapered, sometimes leaning or bent; crown large, more-or-less flat-topped and supported on several large up-pointing limbs, foliage diffuse. Often gregarious in sometimes huge pure stands.

Distribution

Throughout the Solomon and Santa Cruz Islands except Guadalcanal and San Cristobal; Moluccas, New Guinea, Bismarcks and throughout Micronesia.

Distribution on Kolombangara

On Kolombangara CAMB is more common in west coast than north coast forests, and in the north is mainly an upland species (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit is a magenta-coloured drupe of diameter 5mm (Whitmore 1974). There are 20,000–52,000 air-dry seeds kg^{-1} (mean 38,000 seeds kg^{-1}) after removal of the flesh (Chaplin 1988b).

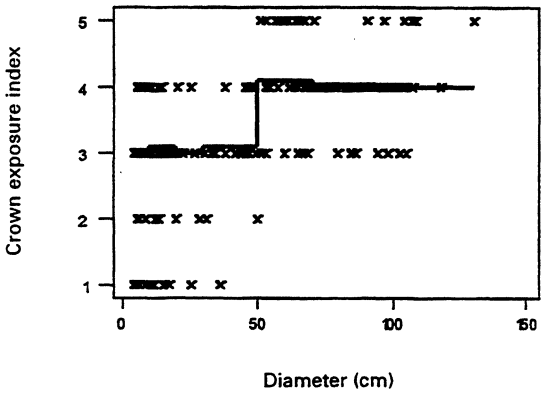
Seedling demography and ecology

Seedling populations size is either small (120 seedlings ha^{-1}) or sometimes medium (120 seedlings ha^{-1}), and tends to be larger and more frequently replenished on the west coast or where there are abundant mature trees. Very high seedling densities (to an equivalent of 190,000–200,000 seedlings ha^{-1} over small areas) are restricted to logged forests where mature trees are present, or beneath obvious bird perches. Recruitment is infrequent except following cyclone or logging damage to the canopy, and even then only occurs where mature trees are present. Seedling establishment occurs in both high forest or canopy gaps, but onward growth of seedlings is only possible in canopy gaps (Whitmore 1974). These characteristics lead to a classification of CAMB as having pioneer index 2 by Whitmore (1989).

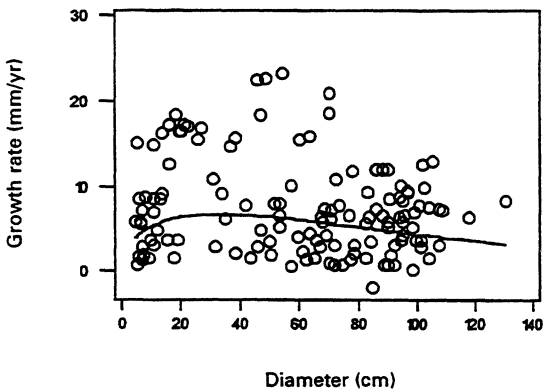
Crown exposure (Fig.5)

Camptosperma brevipetiolatum, and ENDM, possess the highest median crown exposure index (3.0) for stems $\leq 10\text{cm}$ diameter, but the median value then hardly changes for stems up to 50cm diameter and only increases to 4.0 for stems $> 70\text{cm}$ diameter. As a result, although CAMB is one of the least shade-tolerant species among the smaller size classes, only DILS, POMP and SCHS showed a lower median index among stems $> 30\text{--}50\text{cm}$ diameter. A few individuals $> 50\text{cm}$ diameter were recorded as emergents.

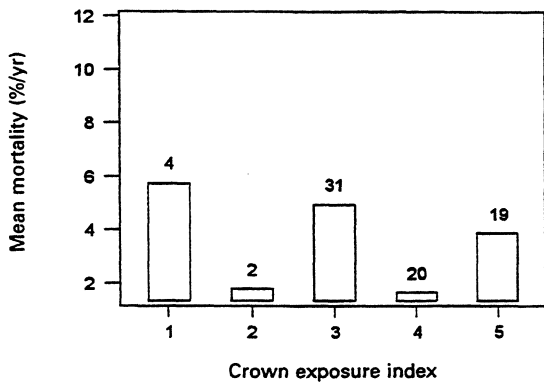
Figure 5 *Camposperma brevipetiolatum*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964-1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967-February 1968). The number of trees dying in each class is shown

Diameter growth rates (Fig.5)

Median diameter growth rate increases from 4.3mm yr⁻¹ for stems ≤10cm diameter to 16.0mm yr⁻¹ for stems >20–30cm diameter, then declines with increasing size class, to 5.3mm yr⁻¹ for stems >70cm diameter. Only ENDM has a greater median growth rate in the size class range 10–20cm diameter, and only ELASP grows faster in the size class range >20–50cm diameter. However, only four species (DILS, ENDM, POMP and TERCAL) have lower median growth rates than CAMB in the highest size class, reflecting the significant decline in the growth of CAMB above 30cm diameter. Maximum growth rates of CAMB decline with size class, from c. 3.0cm yr⁻¹ among stems ≤10cm diameter, to c. 2.0cm yr⁻¹ among stems >70cm diameter.

Mortality rates (excluding cyclone effects)

Mean annual mortality rate decreases from 9.7% yr⁻¹ for stems ≤10cm diameter to 0.2% yr⁻¹ for stems >30–50cm diameter then increases to 3.1–3.5% yr⁻¹ among stems >70cm diameter. CAMB therefore exhibits the expected relation between size and mortality rate, the highest rates being found among small, shaded, and large, senescent, individuals. CAMB exhibits the second highest mortality rate among stems ≤10cm diameter (exceeded only by ENDM) and the highest mortality rate found among stems >70–100cm diameter. However, outside these size classes mean annual mortality rates of CAMB are not particularly high compared to other species, and for stems of >30–50cm diameter mortality rates are very low (0.2% yr⁻¹).

Response to cyclone

Eleven percent of trees (15 individuals) died during the interval spanning cyclone Annie (August 1967–February 1968), a value which is greater than the mean for all species combined (7%). Recruitment of stems above 4.85cm dbh has been recorded at all enumerations since February 1971, with the exception of April/May 1989, although there have been major changes over time in the annual rate of recruitment. In the interval February 1971–September/October 1975 recruitment of CAMB was higher (5.5%yr⁻¹) than all species apart from ENDM and ELASP while recruitment in the next interval, to February/March 1979 (7.4% yr⁻¹), was exceeded only by ELASP. Recruitment of CAMB dropped to zero during November 1985–April/May 1989 and then increased, to 4.8% yr⁻¹, during June/July 1991–February 1994. At the 1975 enumeration 23.5% of all new recruits were CAMB on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 21.7% of new recruits on plots only lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

Camposperma brevipetiolatum was planted on a large-scale by the Forest Division between 1967 and 1987 (9295ha in total) more extensively than any other single species (38.5% of total). Planting was discontinued because bole length and stem form of plantation stock are poor, and because of difficulties with seed handling and storage (Chaplin 1993). Inventory data have also shown that growth rates, stocking and potential yields have been below expectation (Turnbull 1986). Before plantation establishment was discontinued CAMB was close-line planted at spacings of 5 x 3m (667 stems ha⁻¹) or 4 x 3m (833 stems ha⁻¹). immediately after site clearance (Chaplin 1993). Rigorous weeding is necessary, especially in the first six months. Two thinnings of up to 50% achieves the desired final crop stocking of 150–250 stems ha⁻¹. This regime leads to potential yields of 200–300m³ ha⁻¹, harvesting trees of 40cm diameter and 30m height

on a 30+ year rotation, although these yields are unlikely to be achieved in practice. A graphical illustration of growth rates of diameter and height of trees in plantations and research trials is presented by Chaplin (1993). Trees in natural forest show a major decline in growth rate above 30cm diameter and a significant effect of total plot basal area on growth rates, suggesting that the high growth rates of young trees in plantations may not be maintained as the trees mature. Silvicultural treatment, reducing basal area by thinning, would be expected to maintain higher growth rates.

Wood properties

Logs are susceptible to end-spitting and to attack by pin-hole borer and termites where the bark has been broken, but sapwood is immune to attack by *Lyctus* beetles. There is a pith of approximately 2.5cm diameter, and the log always floats. Wood density averages 330kg m⁻³ and the timber is soft with low strength properties (Anon. 1976). The sapwood is a pale brown to pale pink colour and the heartwood similar except sometimes slightly pinker and more lustrous (Anon. 1976). The timber from natural forest has a straight or interlocked grain and frequently contains tension wood (Anon. 1976), although it saws easily (Pleydell 1970). A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

Camposperma brevipetiolatum can be peeled for production of paint grade face veneer and construction veneer in plywood (Pleydell 1970). It also has uses as a general purpose timber for siding and sheathing, shelving, furniture, blackboards, drawing boards, packing cases, boxes, instrument cases, splints and mouldings (Pleydell 1970).

4. *Dillenia salomonensis* (C.T. White) Hoogl.

Family: Dilleniaceae

Forest Division abbreviation: DILS

Kwara'ae name: Mudi

Stout tree to 100 (-210)cm diameter; bole columnar usually with steep thick buttresses; crown with spreading thick limbs; subgregarious; probably the world's biggest *Dillenia*.

Distribution

Shortland Islands, Southern Choiseul, throughout New Georgia Islands, Santa Ysabel, Malaita (for map see Whitmore 1966, p.63).

Distribution on Kolombangara

On Kolombangara DILS is restricted to lowland forests on the west coast (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit of DILS is small and the seeds arillate (Whitmore 1974).

Seedling demography and ecology

Seedling populations are of medium size (30–100 seedlings ha⁻¹) and tends to be largest in the presence of mature trees nearby. Although seedling populations occur on all west coast plots, recruitment is localised and infrequent, averaging once per plot between 1964 and 1971, and not influenced by the 1967 cyclone up to the 1971 enumeration. Mortality rates are low but continuous, leading to a stable population over the 6.6yr of observations (Whitmore 1974). Establishment and onward growth of DILS seedlings only occurs under high forest conditions, leading to classification as pioneer index 1 (Whitmore 1989).

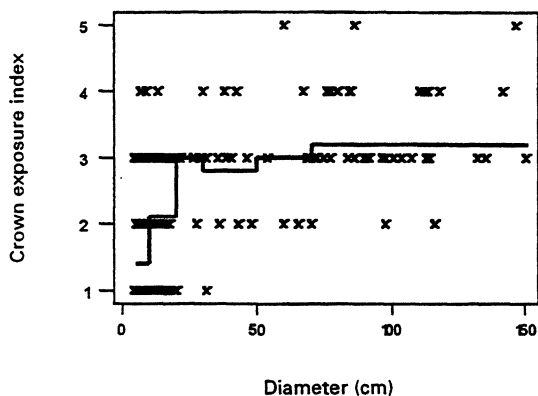
Crown exposure (Fig.6)

Although DILS shares with CALN the lowest median crown exposure index among stems ≤10cm diameter (1.4), median values for DILS increase more slowly with size class and hardly change across the range >20–>70cm diameter, resulting in stems of DILS being the least exposed of all species studied in virtually all size classes. A small number of stems >50cm diameter were classified as emergents.

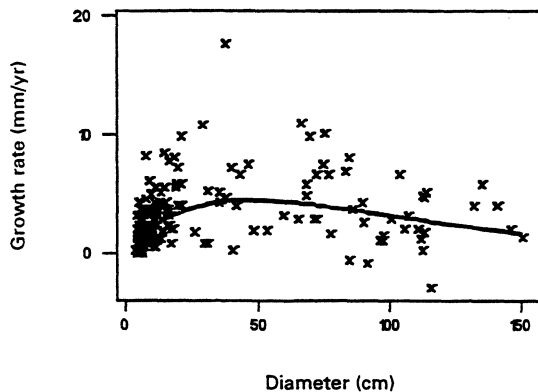
Diameter growth rates (Fig.6)

Median diameter growth rates increase from 1.2mm yr⁻¹ for stems ≤10cm diameter to 4.9mm yr⁻¹ among stems >50–70mm yr⁻¹ then decrease to 3.2mm yr⁻¹ among stems >70cm diameter. Although these figures are low by the standards of the twelve species studied on Kolombangara, only three of these species (CALN, CAMB and PARP) have greater median growth rates than *Dillenia* in all size classes. Maximum growth rates vary

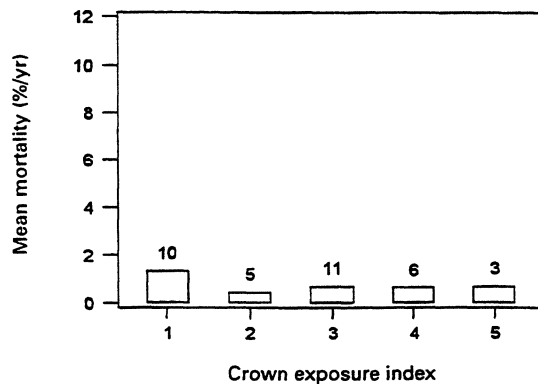
Figure 6 *Dillenia salomonensis*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

between *c.* 1.0cm yr⁻¹ and *c.* 2.0cm yr⁻¹ and are notable in the smallest and highest size classes. Among stems ≤10cm diameter only *Camptosperma* possesses a higher maximum growth rate than DILS, while for stems >70cm diameter only ELASP and PARP have greater maximum growth rates. DILS therefore combines a tendency for slow growth with a capacity for very rapid growth under certain circumstances.

Mortality rates (excluding cyclone effects) (Fig.6)

Mean annual mortality rates decreases from 1.6% yr⁻¹ for stems ≤10cm diameter to 0.0% yr⁻¹ among stems >30–50cm diameter, then increases to 1.2% yr⁻¹ among stems >70cm diameter. Therefore, as with CAMB, mean annual mortality rates are greatest at the extremes of the size class range, reflecting a greater probability of death among small shaded individuals than at intermediate sizes. However, mean annual mortality rates of DILS are much lower than for CAMB and most other species; among stems ≤10cm diameter only *Calophyllum* CALP (0.6% yr⁻¹), MARC (1.0% yr⁻¹) and SCHS (0.2% yr⁻¹) have a lower mean annual mortality rate than DILS (1.6% yr⁻¹) and for all stems >10cm diameter the mean rate for DILS (0.6% yr⁻¹) is equal to the lowest encountered.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 2.8% (5 individuals), a value which was significantly lower than the mean for all species combined (7%). New recruits have been recorded at all enumerations since September/October 1975, but the rate of recruitment has been consistently low and has shown a trend to increase over time, from 0.7% yr⁻¹ during September/October 1975–February/March 1979 to 4.0% yr⁻¹ during June/July 1991–February 1994. This pattern is consonant with the dynamics of the seedling populations described above. At the 1975 enumeration new recruits of DILS were only recorded on plots which had been lightly disturbed by cyclone Annie (mortality < 10% of total basal area) where they constituted 10.9% of the total number recorded.

Plantation experience

A number of trial plots have been established, but the species has never been planted on a large scale by the Forest Division (Sandom 1978). Growth rates and form were very poor in the trial plot at Gizo and the species was not recommended for planting (Sandom 1978). The slow growth of DILS is confirmed by data from the KES plots (Whitmore 1974).

Wood properties

Logs have a tendency to end-split and sometimes contain a blue/black stain, but are not susceptible to either *Lyctus* beetle or pin-hole borer attack (Anon. 1976). Wood density is high, approximately 550kg m⁻³, and logs never float. Timber has high strength, hardness and toughness properties and contains abundant silica (Anon. 1976), but durability is sometimes low (Pleydell 1970). The grain is either straight or interlocked and the texture is intermediate. Sapwood is orange-brown to pink in colour and heartwood is a rich reddish-brown darkening on exposure. A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

Dillenia salomonensis can expose a decorative grain when quarter-sawn and can be used for panelling, furniture and flooring when processed in this way (Pleydell 1970). General purpose uses include construction (boat building, flooring, stairs, posts, beams, sills, frames, piling, fencing), gunstocks and sleepers for railways.

5. *Elaeocarpus sphaericus* (Gaertn.) K.Schum.

Family: Elaeocarpaceae

Forest Division abbreviation: ELASP

Kwara'ae name: Milo

A rather slender tree to 24 (36)m tall and 50 (120)cm diameter with steep plank kneed buttresses to 5m; leaves clustered at branch ends. Primary and secondary forests.

Distribution

Widespread in Solomon Islands. From India and Sri Lanka, throughout Malesia, Bismarcks, Vanuatu, Samoa, not Fiji (Whitmore 1966).

Distribution on Kolombangara

On Kolombangara ELASP is much more common in north coast than west coast forests (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit of ELASP is a bright blue, thinly-fleshed drupe of diameter 18mm (Whitmore 1974).

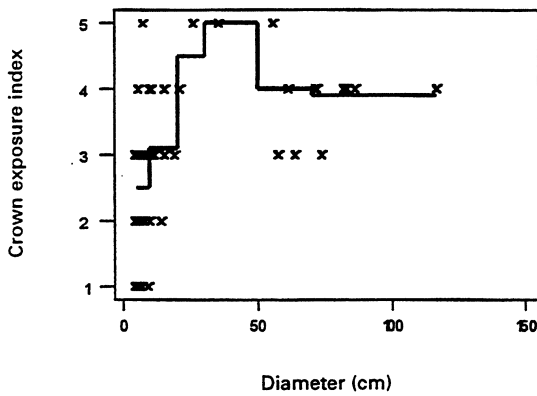
Seedling demography and ecology

Seedling populations are ubiquitous even away from mature trees. Populations tend to be medium (30–50 seedlings ha⁻¹) in size, or rarely to 240 seedlings ha⁻¹. Recruitment and mortality tends to be very low except in north coast forests of type VI, where flushes of 17–125 seedlings ha⁻¹ occur followed by heavy mortality. There was apparently no relation between these flushes and canopy damage due to the 1967 cyclone (Whitmore 1974). Seedling establishment of ELASP occur under high forest conditions but canopy gaps are required for onward growth. These characteristics result in a classification of the seedling ecology of ELASP as corresponding to pioneer index 3 (Whitmore 1989).

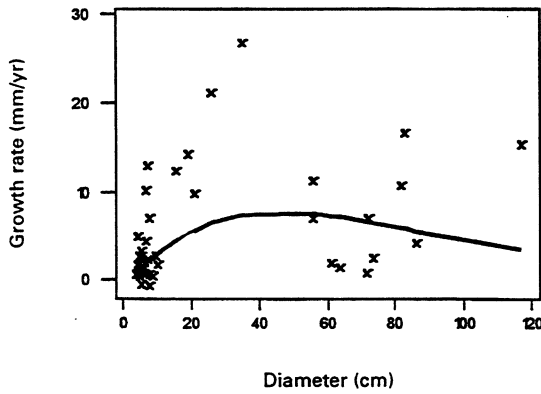
Crown exposure (Fig.7)

Median crown exposure index of ELASP stems ≤10cm diameter (2.5) is greater than all other species apart from CAMB and ENDM and appears to increase rapidly with size class, although the sample size is very small in the range >20–50cm diameter. The incidence of emergent trees was greater than any other species and these were recorded in much lower size classes. Above 50cm diameter median crown exposure of ELASP was in the centre of the range covered by the twelve species.

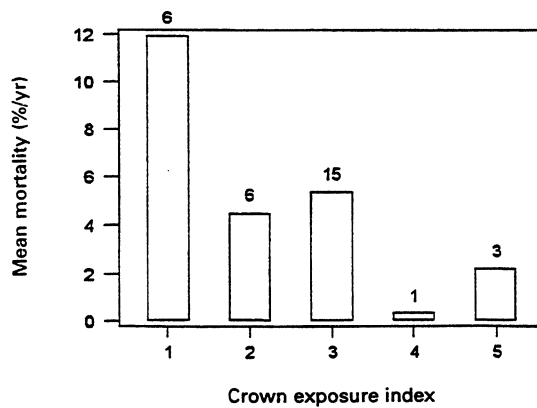
Figure 7 *Elaeocarpus sphaericus*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

Diameter growth rates (excluding cyclone effects) (Fig.7)

Median growth rates of ELASP increase from 1.2mm yr⁻¹ for stems ≤10cm diameter to 19.8mm yr⁻¹ for stems >30–50cm diameter, then fluctuate, between 2.7mm yr⁻¹ for stems in the range >50–70cm diameter to 6.9mm yr⁻¹ for stems >70cm diameter. The performance of ELASP relative to other species differs considerably according to size class. For stems ≤10cm diameter, only GMEM and TERCAL have lower growth rates, and growth rates of DILS are equal to those of ELASP in this size class. However, median growth rates in the range >10–20cm diameter are greater than all but two other species (CAMB, ENDM), and are considerably greater than all other species in the diameter class range >20–50cm. The situation then reverts completely for median growth rates of stems of >50–70cm diameter, which is lower than all species except ENDM. Median growth rate of stems >70cm diameter is back in the highest quarter of the twelve species compared in this study. Maximum growth rates of ELASP varies between 1.8cm yr⁻¹ and 4.5cm yr⁻¹, the upper limit being considerably greater than that of the next placed species. In summary, growth rates of ELASP are very high compared to other species in the diameter class range (>10-) >20–50cm and are potentially high in all size classes.

Mortality rates (excluding cyclone effects) (Fig.7)

Mean annual mortality rates of ELASP are almost identical for all stems ≤10cm diameter (4.7% yr⁻¹) and >10cm diameter (4.5% yr⁻¹). There is no obvious trend in mean annual mortality with size class for stems >10cm diameter, in part because sample sizes for the analysis are rather low. However, the decline in mortality with size up to c. 30cm diameter that is evident for some species certainly does not occur for ELASP, although there was a decline to 0% yr⁻¹ for stems >30–50cm and an increase to a maximum rate of 14.3% yr⁻¹ among stems >100cm diameter. In general, mean annual mortality rates of ELASP are high compared to other species, being greater than all species other than CAMB, ENDM, GMEM and TERCAL for stems ≤10cm diameter, and higher than all other species for all stems >10cm diameter.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 18.6% (8 individuals), a value which is significantly greater than the mean for all species combined (7%). Recruitment since cyclone Annie has tended to be higher than all other species, showing maximum peaks during the intervals February 1971–September/October 1975 (13.3 yr⁻¹) and June/July 1991–February 1994 (20.8% yr⁻¹). During both these intervals recruitment of ELASP was greater than any other species. After the first peak recruitment fell consistently with each time interval and reached zero during April/May 1989–June/July 1991, before rising rapidly to the second peak. At the 1975 enumeration 23.5% of all new recruits were ELASP on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 15.2% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

A number of trial plots have been established, but the species has never been planted on a large scale by the Forest Division (Sandom 1978). Growth of trees on most trial plots slows down after an initial period of rapid growth. Form and survival are also poor, and the species was not recommended for further research (Sandom 1978). On the KES plots diameter growth slowed from median values of 19.8mm yr⁻¹ for trees of >30–50cm

diameter to 2.7mm yr⁻¹ for trees >50–70cm diameter, and mortality rates of trees >10cm diameter were very high. These findings support the conclusions derived from trial plots that ELASP is unlikely to be a successful plantation species.

Wood properties

Logs are often buttressed and have a tendency to end-split. They are also susceptible to pinhole borer, *Lyctus* beetle attack and blue stain fungus (Anon. 1976). The timber has an average density of 350kg m⁻³ and low strength properties. Durability is low. Sapwood is greyish-yellow in colour and heartwood is lustrous straw to pale-brown. The texture is intermediate and the grain either straight, slightly interlocked or wavy. The timber is easy to saw and turn. A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

Few uses have been reported, but Pleydell (1970) suggests that the timber would be suitable for indoor applications, such as peeling for face material and for mouldings and joinery.

6. *Endospermum medulosum* L.S. Smith

Family: Euphorbiaceae

Forest Division abbreviation: ENDM

Kwara'ae name: A'asa

A tall, slender, often poorly-formed tree to 70 (90)cm diameter; bole usually twisted, often leaning; sometimes with steep buttresses.

Distribution

Widespread, scattered throughout Solomon and Santa Cruz Islands, Bismarcks and New Guinea (Whitmore 1966).

Distribution on Kolombangara

On Kolombangara ENDM occurs mostly in lowland forests on the north coast (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit of ENDM is a grey-green, ovoid, tomentose berry 0.65cm long and containing a single seed (Whitmore 1974). There are about 30,000 dry seed kg⁻¹ (Ngoro 1988).

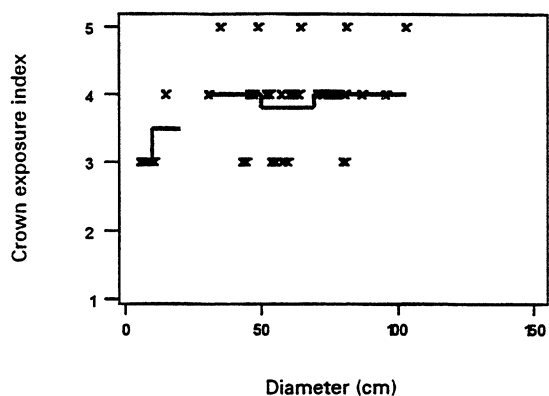
Seedling demography and ecology

Seedling populations of ENDM are present in the north coast forests (313 seedlings ha⁻¹), but virtually absent from west coast forests except medium-sized populations (37–75 seedlings ha⁻¹) on two plots of forest type II. Recruitment of 20–150 seedlings ha⁻¹ occurred in response to the 1967 cyclone and most of these individuals died. Otherwise recruitment was very low and accompanied by a high mortality rate of new recruits (Whitmore 1974). The seedlings of ENDM mostly become established in canopy gaps or extensive clearings, where it occurs gregariously amongst the initial colonisers. Canopy gaps are also necessary for onward growth, leading to a classification of pioneer index 4 (Whitmore 1989).

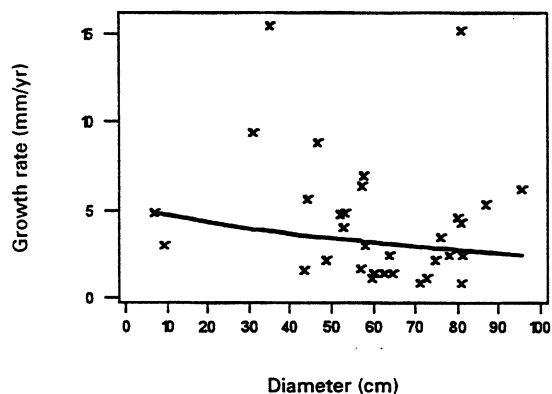
Crown exposure (Fig.8)

Median crown exposure is particularly high for stems ≤10cm diameter (3.0), and equalled only by CAMB. The sample size of stems in the range >10–30cm diameter was too low to allow comment. The relatively high median crown exposure of ENDM is maintained for stems in the range >30–50cm diameter (4.0), but fails to increase among higher size classes, resulting in a decline in the rank crown exposure among the twelve species for stems >50cm diameter. Emergent stems were recorded in all size classes >30cm diameter.

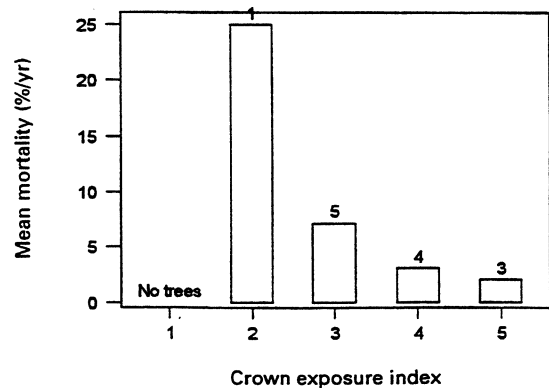
Figure 8 *Endospermum medulosum*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

Diameter growth rates (Fig.8)

Median growth rates increase from 4.8mm yr⁻¹ for stems ≤10cm diameter to 9.5mm yr⁻¹ of >10–20cm diameter then decrease to 2.8mm yr⁻¹ for stems >70cm diameter. ENDM has the highest growth rates among the twelve species studied for stems ≤20cm diameter, but median growth rates relative to other species decline with increasing size class. ENDM has the lowest median growth rate for stems >70cm diameter among the twelve species. Maximum growth rates of ENDM are not high compared to other species, although sample sizes tend to be low for the smaller size classes.

Mortality rates (excluding cyclone effects) (Fig.8)

Mean annual mortality rate decrease from 14.3% yr⁻¹ among stems ≤10cm diameter to 2.7% yr⁻¹ among stems >10cm diameter, although the sample size on which the former value is based is very low (n=14). Above 10cm diameter there is a very rapid increase in mean annual mortality, to 33.3% yr⁻¹, among stems >10–20cm diameter (n=6), followed by a decline to low or medium rates in the range >20–100cm diameter and a return to an exceedingly high rate (33.3% yr⁻¹) for stems >100cm diameter (n=3). It is difficult to make comparisons mortality rates with other species because the sample are so low. However there can be little doubt that ENDM experiences a considerably greater mortality rate than all other species in the study, particularly for stems ≤10cm diameter (14.3% yr⁻¹). For all stems >10cm diameter mean annual mortality rate of ENDM (2.7% yr⁻¹) is similar to that of CAMB (2.6% yr⁻¹) and CALN (2.4% yr⁻¹), but much less than that of ELASP (4.5% yr⁻¹).

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 4.2% (1 individual), a value which is lower than the mean for all species combined (7%). Recruitment of stems above 4.85cm dbh has only occurred twice, i.e. during August 1968–February 1971 (1.9% yr⁻¹) and February 1971–September/October 1975 (7.1% yr⁻¹), the value during the second interval being greater than all species other than ELASP. At the 1975 enumeration new recruits of ENDM were only recorded on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area), where they constituted 9.9% of the total.

Plantation experience

A large number of trial plots have been established, but the species has never been planted on a large scale by the Forest Division (Ngoro 1988). Growth in trial plots has been promising, with 23-year old trees on Baga attaining 50cm diameter and 30m height, but the very high growth rates of young trees is not maintained (trees 3–4 years old have a diameter half that of trees 23 years old). The major constraint on plantation development would be the availability of seedlings because attempts at seed collection have not been successful (Ngoro 1988). Immature seeds are eaten by parrots and mature seeds are often empty. As a result trial plot establishment has been carried out using wildings brought on in the nursery in pots (Ngoro 1988). The KES data add support to the suggestion that growth rates of ENDM decline drastically with age, and suggest that commercial rotations of the species, if it were adopted, would be very short.

Wood properties

Logs are very susceptible to both pinhole borer attack and blue stain fungus and must be extracted quickly. The timber is of low density (approximately 370kg m^{-3}), with low strength properties and is non-durable. Both sapwood and heartwood have an even straw colour which lightens to creamy white on exposure. The texture is even and intermediate and the grain usually straight, but sometimes slightly interlocked or wavy. Tension wood is sometimes present. In general the timber is easily worked with hand tools. A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

The timber is only suitable for lightweight indoor applications such as kitchen furniture, light cabinet work, mouldings, frames, shoe heels, rotary cut veneers, coffins, handicrafts and pattern making (Pleydell 1970).

7. *Gmelina moluccana* (Bl.) Backer

Family: Verbenaceae

Forest Division abbreviation: GMEM

Kwara'ae name: Arokoko

A large tree to 100cm diameter; bole tapering, sometimes leaning or twisted; buttresses to 3m running into flutes to 9m; crown smallish. Disturbed forest, locally common.

Distribution

Solomon Islands and westwards to the Moluccas, including New Guinea and New Britain, also known from the Santa Cruz Islands (Whitmore 1966)

Distribution on Kolombangara

On Kolombangara GMEM has a general distribution but abundance does not clearly correlate with altitude or topography (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit is a conical to cylindrical drupe with a flat, slightly hollow base and dimensions 18 x 13mm. The thin flesh ripens purple and encloses a four-seeded stone (Lonnie 1991, Whitmore 1974).

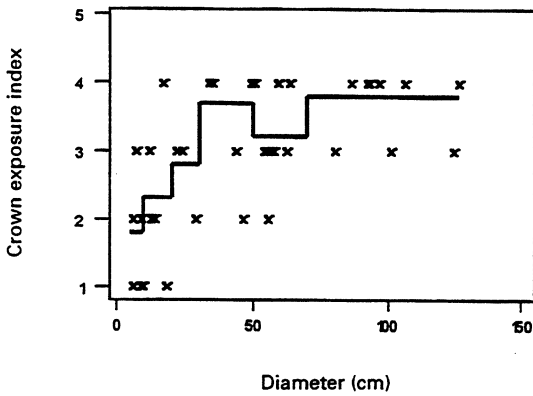
Seedling demography and ecology

Seedling populations are very small (1.7–7.5 seedlings ha⁻¹) and completely restricted to the lowland forest types even though a few adult trees occurred in the higher-altitude forest types III and VI. Recruitment is rare and tends to be of scattered, solitary individuals except on plots severely damaged by the cyclone (e.g. 23 new recruits on plot 10 within 9 months of the cyclone). A tendency to gregariousness in the earliest stages of succession in large clearings has also been noted in relict logged forest where the top of the canopy has been left undisturbed (Whitmore 1974). A requirement for canopy gaps for establishment and onward growth of seedlings lead to pioneer index 4 classification (Whitmore 1989), although it has been suggested that seedlings of GMEM are more tolerant of shade than seedlings of ENDM which is classified in the same group (Whitmore 1974 quoting K.D. Marten, pers. comm.).

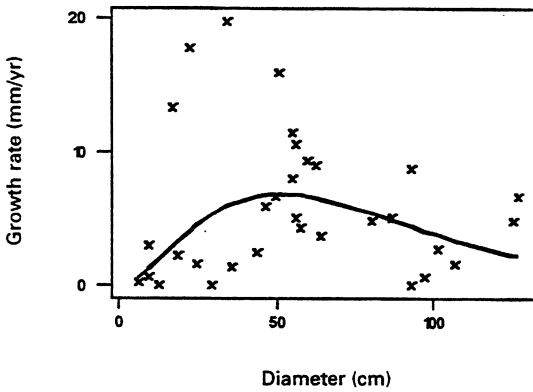
Crown exposure (Fig.9)

Median crown exposure increases from 1.8 for stems ≤10cm diameter to 3.8 for stems >70cm diameter. In the smallest size class median crown exposure (1.8) is intermediate between the highly exposed species (CAMB, ELASP, ENDM) and the most shaded species (both *Calophyllum* species, DILS). Median crown exposure does not increase greatly above 30cm diameter, resulting in a relatively low median value for stems >70cm diameter (3.8), despite the relatively high median value for stems >30–50cm diameter (3.7). Emergent trees were not encountered.

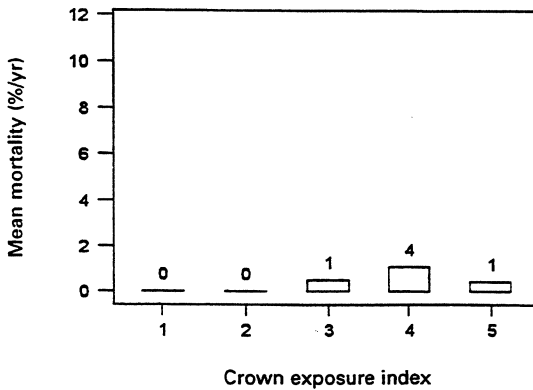
Figure 9 *Gmelina moluccana*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964-1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

Diameter growth rates (Fig.9)

Median diameter growth rate increases from 0.5mm yr⁻¹ among stems ≤10cm diameter to 6.6mm yr⁻¹ among stems >50–70cm diameter. The median and maximum values for stems ≤10cm diameter are lower for GMEM than any other species, but increase in relation to other species with increasing size class. However, median growth rates of GMEM are never high and only enter the top half of the rank hierarchy among stems >50cm diameter.

Mortality rates (excluding cyclone effects) (Fig.9)

Mean annual mortality rate decreases from 5.9% yr⁻¹ for stems ≤10cm diameter to 0.6% yr⁻¹ for all stems >10cm diameter. Mortality is zero for stems in the diameter range >10–50cm diameter and increased among the largest individuals. When compared to other species mortality is relatively high for stems ≤10cm diameter (exceeded only by CAMB, ENDM and TERCAL), but equal to the lowest rates encountered among stems >10cm diameter.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 3.6% (1 individual), a value which is lower than the mean for all species combined (7%). Recruitment of stems above 4.85cm dbh has been infrequent, totalling only six trees over 30 years, and has not been concentrated within any particular time intervals. At the 1975 enumeration recruitment of GMEM only occurred on plots which had been lightly disturbed by cyclone Annie (mortality < 10% of total basal area) and only one new recruit was recorded (2.2% of the total on the plots).

Plantation experience

Trial plots have been established, but the species has not been recommended for large-scale plantation forestry because of consistently poor form and excessive wind damage (Sandom 1978, Ngoro 1988). Growth rates have been variable, never spectacular and often very low (Sandom 1978). Data from the KES plots support the suggestion of low growth rates of *Gmelina*, although mortality rates are also very low.

Wood properties

The log sometimes has poor form, especially the butt logs which may be fluted, but they usually float. Logs are susceptible to blue stain and pinhole borer attack (Anon. 1976). The timber is relatively light-weight, having an average density of 410kg m⁻³, with medium strength properties and moderate to low durability (Anon. 1976). It has an intermediate ('fine', Pleydell 1970) texture grain which is either 'usually interlocked' (Anon. 1976) or 'mainly straight' (Pleydell 1970). Both heartwood and sapwood have a pale colour, the heartwood a lustrous pale straw-brown to orange-brown colour and the sapwood a pale yellow-brown to white colour. The timber has a greasy feel, especially when green, and is hand-worked very easily (Pleydell 1970). A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

The moderate strength and weight makes the timber suitable for general purposes joinery uses, including door frames, shelving, decking and furniture/cabinet work (Pleydell 1970). In Solomon Islands it is the most popular timber for canoe construction as a result of its resistance to decay under conditions of constant wetting and drying. It may also be used for boat building elsewhere, particularly Australia (Pleydell 1970). Peeling tests gave promising results because of a low incidence of end-splits (Anon. 1976).

8. *Maranthes corymbosa* Bl.

Family: Chrysobalanaceae

Forest Division abbreviation: MARC

Kwara'ae name: Aisiksiki

A big tree to 45m tall and 100cm diameter; bole slightly tapering; crown deep, rounded with distinct sub-crowns. Scattered.

Distribution

Solomon Islands, Santa Cruz Islands, Malesia (Whitmore 1966).

Distribution on Kolombangara

On Kolombangara MARC was more common in north coast than west coast forests, although the important factors influencing distribution could not be identified by Greig-Smith *et al.* 1967.

Fruit characteristics

The fruit is a thinly-fleshed drupe with a curved-cylindrical shape and maximum length of 2.5cm. The flesh ripens to a yellow-green colour (Whitmore 1974).

Seedling demography and ecology

The size of seedling populations is very variable, but usually in the range 48–144 (-576) seedlings ha⁻¹. Recruitment occurs as small, local flushes of 14–24 (-72) seedlings ha⁻¹, although one flush of 624 seedlings ha⁻¹ occurred on plot 1, and was followed rapidly by up to 50% mortality. Recruitment of seedlings was not linked to canopy opening caused by the 1967 cyclone (Whitmore 1974). The establishment and onward growth of seedlings occurs mainly in high forest rather than canopy gaps, leading to a pioneer index classification of 1 (Whitmore 1989).

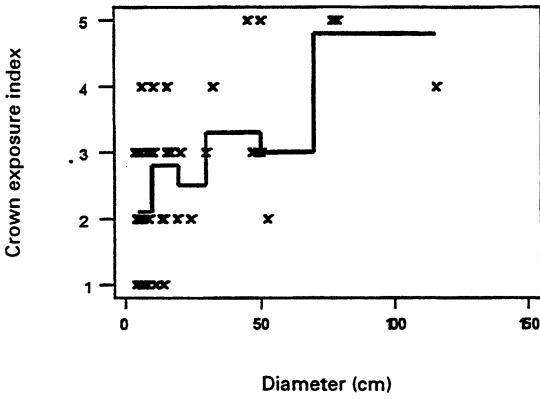
Crown exposure (Fig.10)

Median crown exposure indices for trees ≤20cm diameter are relatively high (2.1–2.8), but subsequent changes with size are not sufficient to maintain the position of MARC in the rank hierarchy of species. Median crown exposure of trees >50–70cm diameter (3.0) is the lowest among the twelve species studied, while median crown exposure of trees >70cm diameter (4.8) is the highest recorded in this category, although the sample sizes available are somewhat low. Emergent trees have been recorded in all size classes greater than 30cm diameter.

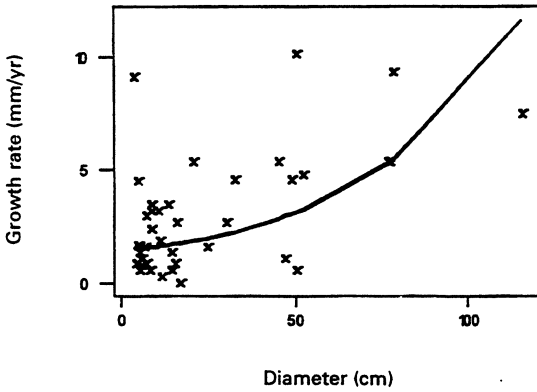
Diameter growth rates (Fig.10)

Median growth rate increases from 1.4mm yr⁻¹ among trees ≤10cm diameter to 6.7mm yr⁻¹ among trees >70cm diameter. Median growth rates are low relative to most other species studied for trees less than 50cm diameter, and particularly so for trees of

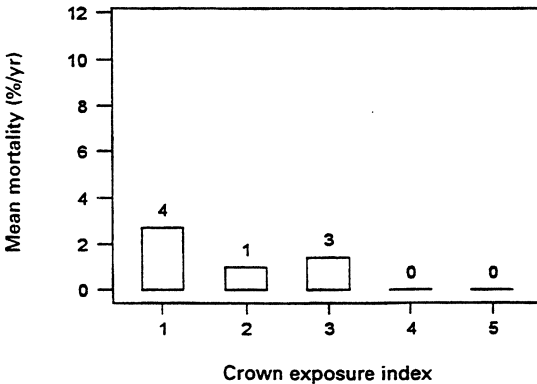
Figure 10 *Maranthes corymbosa*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964-1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967-February 1968). The number of trees dying in each class is shown

>10–20cm diameter. However, the consistent increase in growth rates with size, coupled with peaks in growth rates of other species at intermediate sizes, results in growth rates of trees >70cm diameter being exceeded by only three other species (the two *Calophyllum* species and ELASP). Maximum growth rates are in the range 0.6–1.4cm yr⁻¹ and, with one exception, are the lowest recorded among the twelve study species for trees >20cm diameter.

Mortality rates (excluding cyclone effects) (Fig.10)

Mean annual mortality rate decreases from 1.0% yr⁻¹ among trees ≤10cm diameter to 0.6% yr⁻¹ among all trees >10cm diameter. There is a marked decrease in mortality rate with size class comparing trees of ≤10–30cm diameter (1.0–1.3% yr⁻¹) with trees >30cm diameter (0.0% yr⁻¹). In all size classes mortality rates of MARC are very low compared to other species.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 14.7% (5 individuals), a value which is double the mean for all species combined (7%) and exceeded only by ELASP. Recruitment of stems above 4.85cm dbh was strongly episodic, with new recruits recorded only during February 1971–September/October 1975 (3.0% yr⁻¹), September/October 1975–February/March 1979 (8.1% yr⁻¹) and November 1985–April/May 1989 (8.0% yr⁻¹). At the 1975 enumeration 3.7% of all new recruits were MARC on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 2.2% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

Maranthes corymbosa has not been tried in plantation forestry. The siliceous timber makes this an unattractive species for cultivation, despite the good growth rates of larger trees.

Wood properties

The log is susceptible to pinhole borer attack of the sapwood only and sap-staining fungi have not been reported (Anon. 1979). Timber density and strength are high, with density averaging 720kg m⁻³ (Anon. 1979). The heartwood is red-brown and the sapwood is not distinctive. The timber has a coarse texture with a straight to interlocked grain. Silica and resin are abundant. Sawing is problematic because of the hardness and siliceous nature of the timber. A complete description of mechanical and physical properties is presented by Anon. (1979).

Utilization

The timber is suitable for heavy-duty construction and structural applications, such as piling, jetties, decking and flooring.

9. *Parinari papuana* ssp. *salomonensis* (C.T. White) Prance

Family: Chrysobalanaceae

Common synonym: *Parinari salomonensis* C.T. White

Forest Division abbreviation: PARS (revision to PARP recommended to reflect the name change)

Kwara'ae name: Malaone, Oneone

Big tree to 45m tall, 100cm diameter; bole slightly tapering; buttresses absent or steep and thick; crown fairly deep of several distinct, dense sub-crowns. Locally very common.

Distribution

Solomon and Santa Cruz Islands (Prance 1987).

Distribution on Kolombangara

Parinari papuana subsp. *salomonensis* is widely distributed on Kolombangara and shows no clear correlation with topography (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit is an ovoid thinly-fleshed drupe which reaches a maximum length of about 3cm (Whitmore 1974) or about 4cm (Prance 1987). The flesh ripens to an orange colour with fawn warts (Whitmore 1974).

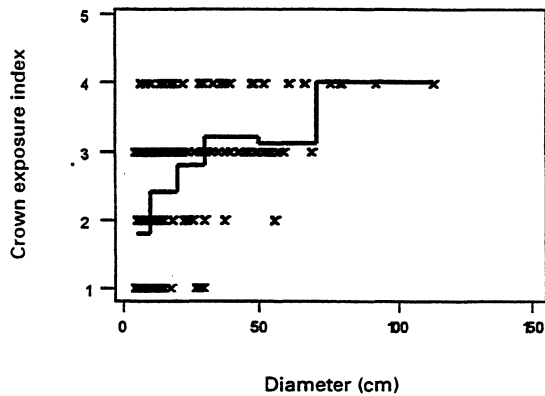
Seedling demography and ecology

Seedling populations occur across all plots on Kolombangara and tend to be of medium size (96–128 seedlings ha⁻¹). Populations of new recruits are rare and small, only once reaching 120 seedlings ha⁻¹ (plot 1), but seedling mortality rates tend to be low also. Recruitment was not coupled to canopy damage caused by the cyclone (Whitmore 1974). PARP seedlings establish and develop in high forest rather than canopy gaps, leading to pioneer index 1 classification (Whitmore 1989).

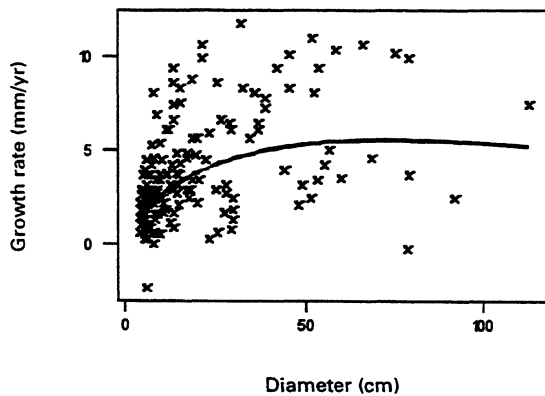
Crown exposure (Fig.11)

Median crown exposure index for trees ≤10cm diameter (1.8) and trees >10–20cm diameter (2.4) are intermediate between the least exposed group of species (both *Calophyllum* species and DILS) and those species, such as CAMB, ELASP and ENDM, with highly exposed crowns. Median crown exposure index of PARP increases incrementally in all size classes up to >30–50cm diameter, in a similar way to the three other species with similar indices for stems ≤10cm diameter (GMEM, SCHS and TERCAL). However, for PARP, there is no additional increase in crown exposure in the next size class, while both SCHS and TERCAL do show an increase. There is a big increase in median crown exposure index of PARP between trees >50–70cm diameter (3.1) and >70cm diameter (4.0), resulting in a value that is again intermediate. Emergent stems were not recorded.

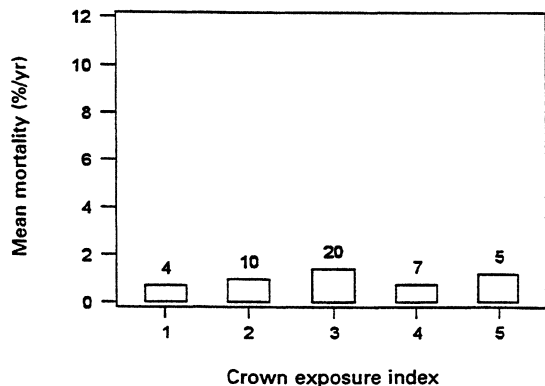
Figure 11 *Parinari papuana ssp. salomonensis*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

Diameter growth rates (Fig.11)

Median growth rate increases from 1.8mm yr⁻¹ for trees ≤10cm diameter to 8.7mm yr⁻¹ for trees >50–70cm diameter, then decreases to 6.7mm yr⁻¹ for trees >70cm diameter. Although the value for the lowest size class (1.8mm yr⁻¹) is not high compared to CAMB and ENDM, it is near the top end of the range for the remaining species. That situation is maintained with increasing size class, so that in the >50–70cm diameter size class median growth rate of PARP is greater than all species other than the two *Calophyllum* species following the early decline in the growth rates of CAMB, ELASP and ENDM. Median growth rates of PARP trees >70cm diameter are higher than most other species, but considerably lower than values for either of the *Calophyllum* species. Maximum growth rates vary between 1.1 and 3.3cm yr⁻¹ and tend to increase with size class.

Mortality rates (excluding cyclone effects) (Fig.11)

Mean annual mortality rate decreases from 1.6% yr⁻¹ among trees ≤10cm diameter to 0.8% yr⁻¹ among all trees >10cm diameter. The decline occurs among trees >10–30cm diameter and stays in the range 0.4–0.9% yr⁻¹ up to 100cm diameter, then declines to 0.0% yr⁻¹ for stems >100cm diameter. All mean annual mortality rates are lower for PARP than for all the twelve species combined, but in all size classes there are at least two species with a lower mean annual mortality rate than PARP.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 5.2% (8 individuals), a value which is lower than the mean for all species combined (7%). Recruitment of stems above 4.85cm dbh has been recorded at all enumerations since February 1971, inclusive, and has varied in the range 0.3–5.1% yr⁻¹. Two major peaks of recruitment have occurred, the first during February 1971–September/October 1975 (2.8% yr⁻¹), 4–8 years after cyclone Annie, and the second during June/July 1991–February 1994 (5.1% yr⁻¹). These peak values are high compared to rates for other species during the same intervals. During February 1971–September/October 1971 only CAMB, ELASP, ENDM and POMP possessed higher recruitment rates than PARP, while during June/July 1991–February 1994 the list reduces to CALN and ELASP. At the 1975 enumeration 11.1% of all new recruits were *Parinari* on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area), compared to 19.6% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

Parinari papuana has not been tried for plantation forestry. The relatively high growth rates of trees on the KES plots and the high quality timber (see below) might justify trial establishment. Silvicultural characteristics are likely to be similar to *Calophyllum*.

Wood properties

The sapwood may be susceptible to pinhole borer attack, although sapstain has not been reported and durability is high. The timber is pale red-brown to red-brown in colour and has high density (mean 660kg m⁻³) and strength properties (Anon. 1979). The grain may be either straight to slight interlocked (Anon. 1979) or wavy (Pleydell 1970), and texture is medium coarse. Abundant silica makes the wood hard, abrasive

and difficult to cut, so hard-tipped saws are necessary (Anon. 1979). A complete description of mechanical and physical properties is presented by Anon. (1979).

Utilization

The timber is suitable for outdoor heavy-duty construction and structural applications, such as piling, jetties and decking, but also for indoor flooring and turnery (Pleydell 1970).

10 *Pometia pinnata* Forst.

Family: Sapindaceae

Forest Division abbreviation: POMP

Kwara'ae name: Ako, Dawa

A rather slender tree to 36m tall, 80 (-120)cm diameter; bole form rather poor, commonly slightly twisted, sometimes fluted near butt; buttresses steep to spreading; crown deep and dense. Very common, often sub-gregarious, in dry lowland forest and old secondary forest.

Distribution

Throughout the Solomon Islands and Santa Cruz Islands; Sri Lanka; Andaman Islands; throughout Malesia and Melanesia to Samoa plus a few scattered stations in continental Asia (Whitmore 1966).

Distribution on Kolombangara

On Kolombangara POMP is much more abundant in north coast than west coast forests and tends to be restricted to northern lowland forests (Greig-Smith *et al.* 1967).

Fruit characteristics

The fruit is ovoid to spherical (2.5cm diameter) with a leathery indehiscent wall ripening red then black. The single seed is entirely enclosed by a thin fleshy aril (Whitmore 1974).

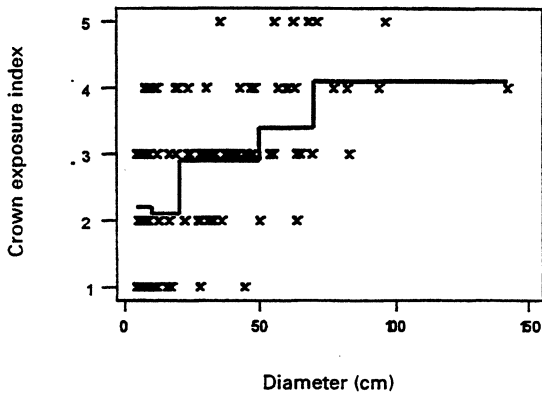
Seedling demography and ecology

As with adult trees, seedlings of POMP are found mainly in the north coast forests and occur as small populations (except in forest type 5 where population size reaches 84 seedlings ha⁻¹). Recruitment is by rare production of seedling cohorts of up to 34 seedlings ha⁻¹ and was not coupled to cyclone damage to the forest canopy. Death rates were low except on those plots severely damaged by the cyclone, leading to a generally stable population structure over the course of the 6.6 yr measurement interval (Whitmore 1974). Although POMP seedlings do not colonise large clearings, establishment is favoured by disturbance and onward growth occurs in either high forest or small canopy gaps (Whitmore 1974). These characteristics justify the inclusion of POMP with the two *Calophyllum* species in pioneer index class 2 (Whitmore 1989).

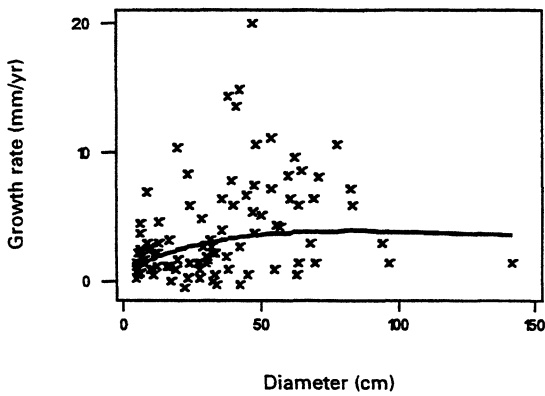
Crown exposure (Fig.12)

Median crown exposure of trees ≤10cm diameter (2.2) is greater for POMP than all species other than CAMB, ELASP and ENDM. However, for POMP, as with CAMB, crown exposure does not increase between the ≤10cm diameter and >10–20cm diameter size classes, with the result that all species other than DILS and CALP possess a greater median crown exposure than POMP for trees >10–20cm diameter. Median crown exposure then increases substantially between the >10–20cm diameter and >20–30cm diameter size classes, but remains constant into the >30–50cm diameter range, again

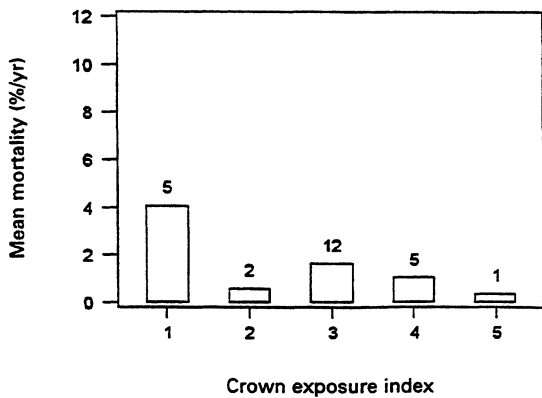
Figure 12 *Pometia pinnata*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

resulting in major changes in the rank position of POMP relative to other species. For trees >50–70cm diameter median crown exposure of POMP is near the centre of the range for the twelve species, but the substantial increase between the >50–70 diameter and >70cm diameter size classes places POMP beneath only two other species (MARC and TERCAL). Emergent trees were recorded in all size classes >30cm diameter.

Diameter growth rates (Fig.12)

Median growth rate increases from 1.3mm yr⁻¹ for trees ≤10cm diameter to 4.9mm yr⁻¹ for trees >50–70cm diameter, then decreases to 3.1mm yr⁻¹ for trees >70cm diameter. These values are low by the standards of the twelve species considered in this study: for trees ≤10cm diameter only four species (DILS, ELASP, GMEM and TERCAL) possess lower median growth rates than POMP; for stems >10–20cm diameter median growth rate of POMP is equal to the lowest encountered in the study; for stems >20–30cm diameter median growth rate of POMP is lower than all species other than TERCAL; for stems >30–50cm diameter POMP is the slowest growing species; for stems >70cm diameter only ENDM possesses a lower median growth rate. The only size class in which POMP grows relatively fast is the range >50–70cm diameter, when DILS, ELASP, ENDM MARC and TERCAL have median growth rates equal to or lower than POMP. Maximum growth rates of POMP vary between 0.8 and 3.2cm yr⁻¹ and tend to be low compared to other species, except in the case of stems >50–70cm diameter.

Mortality rates (excluding cyclone effects) (Fig.12)

Mean annual mortality rate decreases from 3.8% yr⁻¹ among trees ≤10cm diameter to 0.0–0.5% yr⁻¹ among trees >20–100cm diameter and then increases to 8.3%yr⁻¹ among trees >100cm diameter. Therefore, POMP illustrates the expected relation between mortality rate and size class, with the highest rates being found among the small, shaded, and the large, senescent, individuals. The mean annual mortality rate of trees ≤10cm diameter (3.8% yr⁻¹) is greater than the mean for all species (2.2% yr⁻¹), but less than those of CAMB (9.7% yr⁻¹), ELASP (4.7% yr⁻¹), ENDM (14.3% yr⁻¹), GMEM (5.9% yr⁻¹) and TERCAL (9.2% yr⁻¹). Mean annual mortality rates of POMP are lower than most other species in the diameter class range >20–100cm, but greater than all species other than ELASP and ENDM among trees >100cm diameter.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 10.8% (10 individuals), a value which is greater than the mean for all species combined (7%). Recruitment of new stems above 4.85cm dbh has been recorded at all enumerations since February 1971, inclusive, and has varied in the range 0.5–7.1% yr⁻¹. Unlike many other species the highest recruitment rates for POMP did not occur within 12 years of cyclone Annie, although there was an increase, to 4.5% yr⁻¹, in September/October 1975–February/March 1979 followed by a decrease, to 1.2% yr⁻¹, during February/March 1979–November 1985. The highest rate was in fact recorded during April/May 1989–June/July 1991 (7.1% yr⁻¹) at a time when recruitment rates for all other species were very low. As a result POMP had a much greater rate than any other species during this interval. At the 1975 enumeration 7.4% of all new recruits were POMP on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 8.7% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

Trials have been established on a variety of sites, but no large-scale plantations exist (Sandom 1978). Mean annual increment on trial plots is in the range 16–25mm yr⁻¹ of diameter and declines with increasing age (Sandom 1978). The best plots at Baga and Mt. Austen produced 30cm diameter trees in 13–16 years, but form is poor and bole length restricted to 4–8m as a result of low branching under these conditions. The relatively high growth rates of height and the high value of the timber led Sandom (1978) to recommend that further trials of POMP should be conducted. POMP did not show fast growth rates compared to other species on the KES plots, and it may be that growth is allocated to height increment rather than diameter increment in this species, or that the more open conditions associated with plantations improve performance relatively more for POMP than for other species.

Wood properties

Logs are normally sound, free of knots and moderately free of end-splits, although butt-rot may be found in logs from old individuals and the tree has a relatively high degree of taper (Anon. 1976). The log may either float or sink in water depending on the locality. Sapwood is susceptible to *Lyctus* beetle attack but blue-stain fungus and pinhole borer are not usually serious (Anon. 1976). Durability is relatively low. The timber has medium density (mean 590kg m⁻³) and strength properties (Anon. 1976). The sapwood is pale pink brown in colour with an orange tinge, and the heartwood is usually pinkish, but occasionally red and streaky turning brown with age. The texture of the timber is intermediate and uneven (Anon. 1976) to coarse (Pleydell 1970) and the grain may vary from straight and fissile to strongly interlocked and wild. Severe spiral grain was reported by Anon. (1976). Care is needed in the early stages of drying as shrinkage of green material is large (Pleydell 1970). POMP machines easily along and across the grain and has good bending properties. A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

The timber peels well for attractive face veneer production (Pleydell 1970). Otherwise, the high strength/weight ratio and toughness make the timber suitable for a wide variety of uses, such as light constructional work, mouldings, interior joinery, door and window frames, furniture, tool handles, turnery, boat planking and framing, piano construction, beams and joists (Pleydell 1970). In Solomon Islands it is used in house construction, for posts, beams and rafters.

11 *Schizomeria serrata* (Hochr.) Hochr.

Family: Cunoniaceae

Forest Division abbreviation: SCHS

Kwara'ae name: Beabea, Bebea

Big tree to 36m tall, 120 (-140)cm diameter; bole columnar or slightly tapering, sometimes buttressed, sometimes fluted to 3m; crown dense and developing massive limbs with age. Lowland forest to 660m, especially on ridges; common, not gregarious.

Distribution

Throughout Solomon Islands except Santa Cruz Islands; New Britain; New Guinea; Moluccas and possibly Queensland (Whitmore 1966).

Distribution on Kolombangara

On Kolombangara SCHS occurs with near equal abundance in both north coast and west coast forests but tends to be an upland species (Greig-Smith *et al.* 1967). The important factor influencing distribution and abundance was not identified by Greig-Smith *et al.* (1967).

Fruit characteristics

The fruit is a spherical nut of diameter 1.3cm with a thick woody wall (Whitmore 1974).

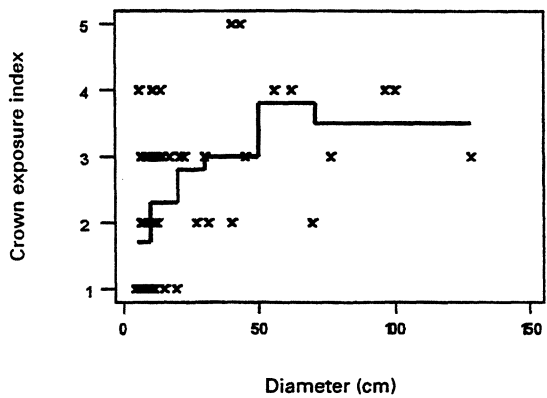
Seedling demography and ecology

The distribution of seedling populations reflect closely the distribution of adult trees, being much larger in high altitude north coast forest types (to a maximum of 72 seedlings ha⁻¹) than west coast forests (minimum <1 seedling ha⁻¹). Recruitment is also more common in north coast forests, but is never frequent or abundant (to 24 seedlings ha⁻¹). Recruitment is followed by considerable seedling mortality and was not coupled to cyclone damage to the canopy (Whitmore 1974). SCHS requires high forest conditions for seedling establishment and onward growth and has not been observed colonising large clearings; hence seedlings are classified as having pioneer index 1 (Whitmore 1989).

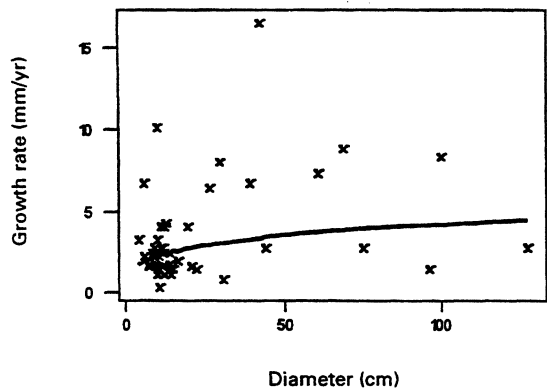
Crown exposure (Fig.13)

Median crown exposure of trees ≤10cm diameter is low (1.7), being greater than the median indices of only three other species (CALN, CALP, DILS), although median indices for trees of GMEM, PARP and TERCAL in this size class are only marginally greater (1.8). Median crown exposure of SCHS increases rapidly with size class, to a maximum (3.8) for trees in the diameter range >50–70cm; there is no further increase among trees >70cm diameter, resulting in a low median crown exposure for trees in this size class relative to all species other than DILS. The pattern of increase in median crown exposure index with size class is very similar for SCHS and PARP in the range ≤10–50cm diameter. For larger size classes the two species diverge: crown exposure of SCHS increases rapidly, to a maximum in the range >50–70cm diameter, then shows no further increase, while median crown exposure of PARP shows no increase between >30–50cm and >50–70cm

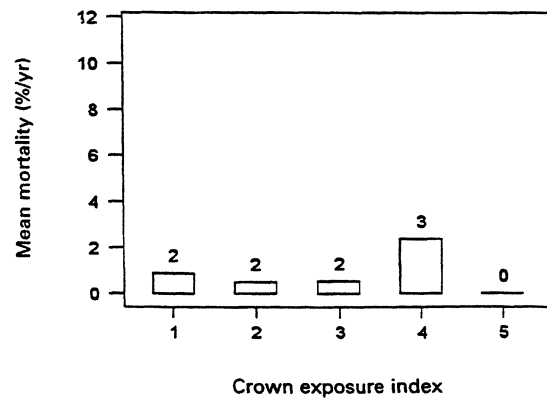
Figure 13 *Schizomeria serrata*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

diameter, but then rises significantly for stems >70cm diameter. For SCHS, emergent stems were recorded in the >30–50cm size class range only.

Diameter growth rates (Fig.13)

Median diameter growth rate decreases initially, from 2.4mm yr⁻¹ among trees ≤10cm diameter to 1.7mm yr⁻¹ among trees >10–20cm diameter, then increases to a maximum of 7.3mm yr⁻¹ among trees >50–70cm diameter, before declining to 5.6mm yr⁻¹ in trees >70cm diameter. Growth rates of trees ≤10cm diameter are high relative to other species with a similar crown exposure, being greater than all species other than CAMB and ENDM. However, the reduction between the first sizes (combined with increases for most other species) result in a median growth rate (1.7mm yr⁻¹) that is only marginally greater than that of the slowest-growing species in this size class (1.6mm yr⁻¹). The rank position of median growth rates of SCHS relative to other species increases with increasing size class, median growth rates of SCHS being greater than four, six and eight species in the >20–30cm, >30–50cm and >50–70cm diameter size classes respectively; in the latter only the two *Calophyllum* species and PARP grow faster than SCHS. The major decline in growth rates of SCHS trees >70cm diameter lead also to a decline relative to other species; ELASP, GMEM and MARC grow faster than SCHS in this size class, as well as the three species mentioned above. Maximum growth rates of SCHS range from 0.8–2.5cm yr⁻¹, but are most often about 1.0cm yr⁻¹. For three size classes maximum growth rates of SCHS are lower than all other species.

Mortality rates (excluding cyclone effects) (Fig.13)

Mean annual mortality rate increases from 0.2% yr⁻¹ among trees ≤10cm diameter to 2.3% yr⁻¹ among trees >10–20cm diameter, then decreases to 0.0–0.8% yr⁻¹ among trees >20cm diameter, except for a very high rate (10.2% yr⁻¹) among trees >50–70cm diameter, possibly reflecting the low sample size (n=18). The value for trees ≤10cm diameter is very low for the size class and by far the lowest recorded among the twelve species, but the values for stems >10–20cm diameter (2.3% yr⁻¹), >50–70cm diameter (10.2% yr⁻¹) and for all stems >10cm diameter (2.0% yr⁻¹) are all relatively high. Among trees >10–20cm diameter and all trees >10cm diameter, only CALN, CAMB, ELASP and ENDM have a mean annual mortality greater than SCHS.

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 6.5% (3 individuals), a value which is similar to the mean for all species combined (7%). Recruitment of stems above 4.85cm dbh has been low (range 0–2.2% yr⁻¹) during the 30-year study period with much less fluctuation between measurement intervals than most other species. Highest recruitment rates were recorded during February 1971–September/October 1975 (1.7% yr⁻¹) and June/July 1991–February 1994 (2.2% yr⁻¹). At the 1975 enumeration 1.2% of all new recruits were SCHS on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area) compared to 2.2% of new recruits on plots lightly disturbed by cyclone Annie (mortality < 10% of total basal area).

Plantation experience

No information.

Wood properties

Sapwood is susceptible to pinhole borer and *Lyctus* beetle attack but not to sap-staining fungi (Anon. 1976). The log sinks. The timber is of medium density (mean 490kg m^{-3}), with moderate hardness and moderate to low strength properties (Anon. 1976). Durability is low for outdoor uses. The sapwood is pale-brown or straw coloured and heartwood is pink to pink-brown and lustrous. The timber has a fine close texture and slightly to moderately interlocked grain (Anon. 1976) but may possess a moderate ribbon figure. SCHS machines easily along and across the grain (Pleydell 1970). A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

The timber has potential for commercial veneer production, and for cabinet work, shelving, interior trim and general joinery (Pleydell 1970).

12 *Terminalia calamansanai* (Blanco) Rolfe

Family: Combretaceae

Forest Division abbreviation: TERCAL

Kwara'ae name: Kako, Kwako, Sualisualo

An elegant tree to 36m tall, 80cm diameter; bole columnar, usually with plank buttresses to 9m; crown small, diffuse. Well-drained forest, mostly ridges, often in groves.

Distribution

Throughout Solomon Islands, New Guinea, Moluccas, Philippines, Peninsular Malaysia, Indochina, Thailand, Myanmar (Whitmore 1966).

Distribution on Kolombangara

On Kolombangara TERCAL is markedly more common in north coast than west coast forests, although the pattern of distribution suggests some factor not recognised by Greig-Smith *et al.* (1967).

Fruit characteristics

The fruit is a tiny winged nut with overall dimensions 25–50mm by 13–20mm (Whitmore 1966). The immature nut is green, but changes to yellow then brown during maturation (Chaplin 1993). There are about 7500 whole fruits kg^{-1} and 13,000 dewinged nuts kg^{-1} (Chaplin 1993).

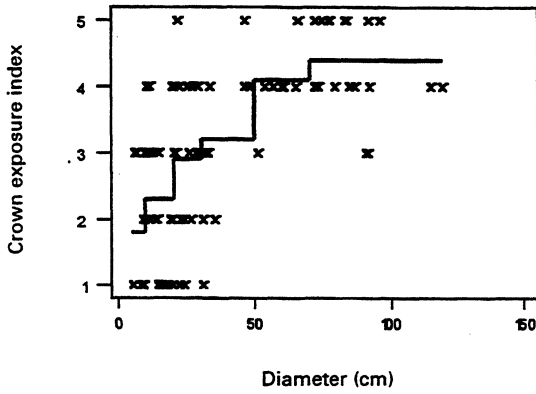
Seedling demography and ecology

Seedlings are almost entirely restricted to north coast forests and the two west coast plots with adult trees. Seedling populations are very variable in size, but tend to be largest at low altitudes in the north. Recruitment is by occasional flushes of 96–2016 seedlings ha^{-1} which show either rapid growth or high mortality rates. Recruitment of 63 seedlings ha^{-1} was stimulated by 100% canopy damage to plot xvii as a result of the 1967 cyclone. Seedlings of TERCAL become established in close proximity to adult trees but soon die unless these sites are beneath a canopy gap or a cyclone causes extensive canopy damage, and canopy gaps are also necessary for onward growth of seedlings (Whitmore 1974). These characteristics result in the classification of TERCAL as having pioneer index 4 by Whitmore (1989).

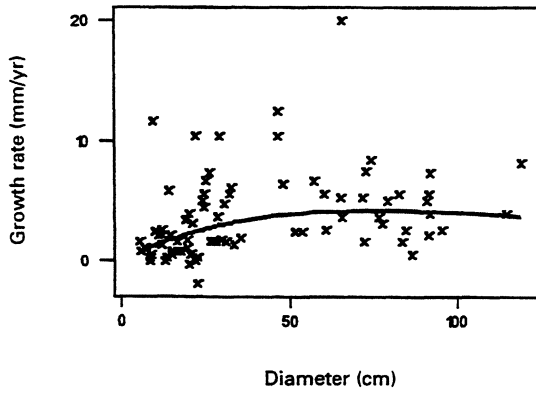
Crown exposure (Fig.14)

Median crown exposure of trees $\leq 10\text{cm}$ diameter (1.8) is in the intermediate group, along with GMEM, PARP and SCHS. These four species also show a very similar pattern of increase in median crown exposure with size class, to values of 2.8–2.9 for trees $>20\text{--}30\text{cm}$ diameter. Above 30cm diameter median crown exposure of TERCAL continues to increase with size class, to a maximum of 4.4 for trees $>70\text{cm}$ diameter, while the three other species in this group all show a maximum at an intermediate size or a range of successive size classes with very little change in median crown exposure. As a result, crown exposure of TERCAL trees $>70\text{cm}$ diameter (4.4) is much greater than the other

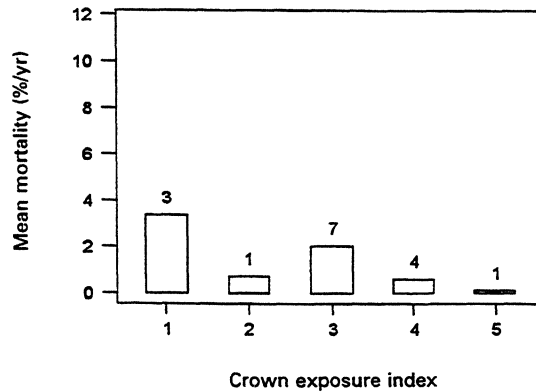
Figure 14 *Terminalia calamansanai*



a Crown exposure index at first observation against tree diameter



b Change in diameter growth rate with tree diameter, 1964–1967, for all trees



c Mean annual mortality rate for trees of different crown exposure index classes

Calculated over all intervals except that containing cyclone Annie (August 1967–February 1968). The number of trees dying in each class is shown

species in this group, and also greater than all remaining species apart from MARC. For TERCAL, emergent stems were recorded in all size classes >20cm diameter.

Diameter growth rates (Fig.14)

Median growth rates of TERCAL show an erratic relation to increasing size class, increasing from 0.9mm yr⁻¹ among trees ≤10cm diameter to 1.6mm yr⁻¹ for trees >10–20cm diameter, then decreasing to 1.1mm yr⁻¹ for trees >20–30cm diameter. Median growth rates are highest among trees >30–50cm diameter (4.8mm yr⁻¹) and decrease, to 3.9mm yr⁻¹, for trees >70cm diameter. In general, these values are low compared to most other species: among trees ≤10cm diameter only GMEM grows slower than TERCAL; and for stems in the range >10–30cm diameter growth rates of TERCAL are equal to or lower than all other species. Trees in the fastest growing size class for TERCAL (>30–50cm diameter) grow slower than all but four other species (DILS, GMEM, MARC and POMP) and the rank position declines further with increasing size class. Maximum growth rates of TERCAL vary in the range 0.9–2.1cm yr⁻¹.

Mortality rates (excluding cyclone effects) (Fig.14)

Mean annual mortality rate decreases from 9.2% yr⁻¹ among trees ≤10cm diameter to 0–0.5% yr⁻¹ among trees >20cm diameter, except for a slight increase (to 1.5% yr⁻¹) among trees >50–70cm diameter. The value for trees ≤10cm diameter (9.2% yr⁻¹) is very high for the size class, and exceeded only by CAMB (9.7% yr⁻¹). The value for trees of >10–20cm diameter (2.3% yr⁻¹) is also relatively high, but values for all other size classes are lower than the means for all species combined. If all trees >10cm diameter are considered, the mean annual mortality rate of TERCAL (0.7% yr⁻¹) is lower than that for all species other than DILS, GMEM and MARC (all showing 0.6% yr⁻¹ mortality).

Response to cyclone

Mortality during the interval spanning cyclone Annie (August 1967–February 1968) was 2.8% (2 individuals), a value which is much lower than the mean for all species combined (7%) and equal (with DILS) to the lowest encountered. Recruitment of stems above 4.85cm dbh was only recorded during February 1971–September/October 1975 (1.4% yr⁻¹) and September/October 1975–February/March 1979 (2.1% yr⁻¹), i.e. peaking 8–12 years after cyclone Annie. These values are low compared to other species, particularly during the first of these intervals when the rates for TERCAL were lower than those of all species apart from DILS and GMEM. At the 1975 enumeration new recruits of TERCAL were only recorded on plots which had been heavily disturbed by cyclone Annie (mortality >10% of total basal area), where they constituted 2.5% of total new recruits. This pattern fits with the ecology of its seedlings, as described above.

Plantation experience

Terminalia calamansanai is classified as a major plantation species because has been widely planted by the Forest Division (Chaplin 1993). A total of 2740ha were established on Kolombangara (1140ha), Viru (1450ha) and the Shortland Islands (150ha) in two phases, 1970–1981 and 1983–1986, a total which represented 11.3% of the Forest Division plantation estate in 1989. Planting was discontinued in 1986 because of the high cost of establishment and high variance in performance. At wide spacing (e.g. 10 x 3m, 333 stems ha⁻¹) establishment is limited by competition with convolvulaceous climbers (mainly *Merremia*) unless regular and expensive weeding is carried out, while

planting at close spacing (e.g. 5 x 3m, 667 stems ha⁻¹) results in delayed canopy closure (Chaplin 1993). Plantation establishment has to occur as soon as possible after site clearance in order to pre-empt site capture by *Merremia*. TERCAL is deciduous and this exacerbates the competition of *Merremia*. Form and growth rates can be outstanding on certain, highly specific, sites and if management is sufficiently intensive in the establishment phase (e.g. plots on Kolombangara and Viru), but average results are below expectation. A fully stocked stand of 150–250 stems ha⁻¹ would yield 200–300m³ ha⁻¹ on a 30–35 year rotation (Chaplin 1993). The growth rates of TERCAL on the KES plots do not reflect the potential for fast growth in plantations.

Wood properties

Logs are usually sound but possess a tendency to end-split and are susceptible to pinhole attack and sap-stain fungi in sapwood and heartwood (Anon. 1976). The timber has a medium to low density (mean 460kg m⁻³) and moderate strength and hardness properties (Anon. 1976). Durability is low as a result of the susceptibility to *Lyctus* beetle attack, blue stain fungus and pinhole borer. The heartwood is pale yellow to pale brown in colour, and the sapwood either similar (Anon. 1976) or sometimes cream (Pleydell 1970). The timber has a coarse or medium texture and straight or moderately interlocked grain, with growth rings. It machines easily along and across the grain, although handsawing is made more difficult by the hardness and the frequent presence of tension wood. A complete description of mechanical and physical properties is presented by Anon. (1976).

Utilization

The timber may be peeled for veneer with effective results, although the high incidence of pinhole borer attack and sap-staining fungi reduce yields (Anon. 1976). *Terminalia* is a useful general purpose timber with greater potential for joinery work in frames and furniture than high-grade cabinet work (Pleydell 1970).

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