

A phytosociological study of mangrove vegetation in Australia with a latitudinal comparison of East Asia

Kunio SUZUKI¹⁾ and Peter SAENGER²⁾

Abstract: Original phytosociological data from 80 stands in New South Wales and Queensland, Australia were classified into 17 types of plant communities in accordance with the concepts and methods of the ZM school. The latitudinal distribution of the main mangrove species in Australia and East Asia and some biogeographical characteristics were discussed from the data collected.

Key words: mangrove vegetation, phytosociology, biodiversity, Australia, East Asia

Introduction

Mangroves are a common and important feature of the sand flats, river banks and coastlines of the tropics and subtropics of the world. They exist at the interface of two environments: land and sea.

The most luxuriant and diverse mangals are found in the humid tropical regions of the world (Macnae 1968). The present distribution of mangroves suggests that the region between Malaysia and northern Australia was the major centre of mangrove flora evolution (Ding Hou 1958, 1972; Specht 1981). On the fossil evidence, Specht (1981) postulated that the centre of the origin of mangroves is more likely to have been the region from south-western and northern Australia to Papua New Guinea rather than the Malaysian Archipelago.

The present mangrove flora in Australia is one of the richest in the world. Twenty-seven species were classed as mangroves by Beadle (1981), while some 39 species of mangroves were recognised by Duke (1992). Approximately half of the world's mangrove species have been identified in Australia.

Many ecological studies have been conducted on mangroves in Australia from a geomorphological and vegetational perspective including Macnae

(1966; 1968), Saenger et al. (1977), Clough (1982) and Robertson and Alongi (1992). However, with the exception of Bridgewater (1985), no studies have attempted phytosociological analyses of these regions.

In this paper, we will discuss some aspects of mangrove vegetation, such as the phytosociological communities in Australia and the biogeographical distribution of mangrove species in East Asia and Australia.

Distribution of mangroves in Australia

Mangroves in Australia are found around most of the mainland coast, except for the southern coastline of Western Australia. They are not found in Tasmania. In Western Australia the southern limit is 33°16'S and in eastern Australia it is Corner Inlet, Wilson's Promontory, Victoria, at 38°45'S. The largest number of mangrove species occurs on the northern and north-eastern coastline. The number of mangrove species declines rapidly with increasing latitude. Lower water and air temperatures as well as the predominance of winter rainfall effectively prevent the southward extension of many species (Hutchings and Saenger 1987).

The southernmost mangroves in the world are a monospecific stand of *Avicennia marina*, found in

1) Faculty of Business Administration, Yokohama National University, Tokiwadai 156, Hodogayaku, Yokohama, 245/Japan

2) Centre for Coastal Management, Southern Cross University, Lismore, Australia

Australia at 38°45'S. Similarly, on the eastern coast of New Zealand, mangroves reach their natural southern limit in the Kutarere arm of Ohiwa Harbour at 38°00'S (Crisp, Daniel and Tortell 1990).

Distribution of mangroves in Japan (East Asia)

Figure 1 shows the distribution of mangroves in Japan. The northern limits of mangrove genera in East Asia are at Kiire (31°22'N), Kyushu in Japan and on the north-eastern part of the Fujian seashore (approximately 26°N) in China. Monospecific *Kandelia candel* was recorded at both sites. The most diverse areas in Japan are on Iriomote Island (southern end of Japan) where 10 species have been recorded: *Kandelia candel*, *Avicennia marina*, *Sonneratia alba*, *Rhizophora stylosa*, *Bruguiera gymnorrhiza*, *Lumnitzera racemosa*, *Heritiera littoralis*, *Excoecaria agallocha*, *Nypha fruticans* and *Acrostichum aureum* (Suzuki 1979, 1981; Miyawaki, Suzuki et al. 1982).

According to Peng (1987), 31 species of mangrove belonging to 20 genera have been recorded in China and 7 species in Fujian Province (23-25°N): *Kandelia candel*, *Avicennia marina*, *Aegiceras corniculatum*, *Acanthus ilicifolius*, *Bruguiera gymnorrhiza*, *Excoecaria agallocha* and *Hibiscus tiliaceus*. *Hibiscus tiliaceus* is not always included as a mangrove species but as a mangrove associate.

Phytosociological study of mangrove vegetation in Australia

This is a preliminary report on a phytosociological study of mangroves in Australia. The purpose of the study was to collect and analyse phytosociological data on mangrove stands on the eastern coast of Australia. The phytosociological investigations were carried out in field surveys in Queensland and New South Wales in Australia during 1995 (figure 2). The phytosociological study sites ranged from Mossman (16°25'S) in north-eastern Queensland to Newcastle (32°52'S) on the central coast of New South Wales.

1. Phytosociological method

The vegetation was studied in accordance with the concepts and methods of the Zürich-Montpellier School (Braun-Blanquet 1964, Miyawaki and Suzuki 1980). It was determined that each selected stand had

to cover a minimum survey space in a habitat which showed homogeneous physiognomy. Thus, the stands were even. All of the species within each stand were checked to make a complete species list by layer. Multistructural communities such as *Rhizophora* forests were divided into three or four layers according to the stands; tree (tree-1 and tree-2), shrub and herb layers. The Braun-Blanquet method was employed to determine the cover class (cover degree-abundance scale) and sociability of the species in each layer.

The cover degree-abundance scale is that originally proposed by Braun-Blanquet in 1964.

- 5 any number of individuals covering more than 3/4 of the area
- 4 any number of individuals covering 1/2 to 3/4 of the area
- 3 any number of individuals covering 1/4 to 1/2 of the area
- 2 great abundance of individuals or covering at least 1/20 of the area
- 1 plentiful but of small cover value
- + sparsely or very sparsely present, covering a very small or insignificant area

Another quantitative estimate per species is the sociability rating. The sociability scale is that originally proposed by Braun-Blanquet in 1964.

- 5 growing in very extensive patches or covering the sample area in one large population
- 4 growing in large groups or colonies, forming patchy carpets, fairly extensive
- 3 growing in small patches, troops, cushions
- 2 growing in small groups or tufts or clumps
- 1 growing singly (the foliage of one plant does not touch another)

The data of releves collected in the field surveys were collated into a raw data table which was then rearranged into a differential table. Finally, the vegetation types were classified into communities by taking into account all of the data available.

2. Plant communities in eastern Australia

The phytosociological data collected during the field surveys were classified into communities. As a preliminary result of the investigation in eastern Australia, it was possible to recognise 17 types of plant communities.

2. 1 *Avicennia marina* community

Location: Fullerton Cove, Newcastle, NSW
(Table 2, Nos 1-10)
Iluka, NSW (Table 3, No. 1)
Yeppoon, Qld (Table 6, No. 1)

The *Avicennia marina* community was differentiated by monospecific *Avicennia marina*. There are usually no associated species. The data for this community were collected from 12 survey points in Newcastle, Iluka and Yeppoon. The community had a height of 2-13 m and a cover of 30-95%. The community is a pioneer or outer fringe mangrove vegetation in northern Australia and is a typical form on the southern coasts of Australia.

Avicennia marina is common in Australian mangroves and is widely distributed to the southern limits. *Avicennia marina* is tolerant of a very wide salinity range, which appears to account for its sporadic distribution from the outer seaward margin in some areas to the inner landward fringe in others, and even in hypersaline patches where the plants are stunted or shrubby (Macnae 1968, Beadle 1981).

2. 2 *Aegiceras corniculatum-Avicennia marina* community

Location: Kooragang, Newcastle, NSW



Map 1 Location map of the phytosociological survey sites in Australia (see tables 1-13)

(Tab. 1, Nos 1-4 and Tab. 3, Nos 1-6)
Iluka, NSW (Table 4, Nos 2-4)
Mobbs Bay, Ballina, NSW
(Table 5, Nos 1-5)
Yeppoon, Qld (Table 6, Nos 3, 4, 6)
Keppel Bay, Qld (Table 6, Nos 2, 5)

The *Aegiceras corniculatum-Avicennia marina* community, which was investigated at 13 survey points, is a two-layered community with *Avicennia* trees and *Aegiceras* shrubs. The surveyed areas were in Iluka and Ballina, NSW, and Yeppoon and Keppel Bay, Queensland. The community had a height of 3-11 m and a cover of 40-95%. Total number of species ranged from 2-5.

The community was widely distributed and often occupied considerable areas on the coasts of southern Queensland and New South Wales. Some of the *Avicennia marina* community pioneered the *Aegiceras corniculatum-Avicennia marina* community.

2. 3 *Aegiceras corniculatum* community

Location: Kooragang, Newcastle, NSW
(Table 3, Nos 7-8)
Iluka, NSW (Table 4, No. 5)

The *Aegiceras corniculatum* community was a common shrub vegetation which was dominated and characterised by *Aegiceras corniculatum*. The *Aegiceras corniculatum* community was found on the front or margin of the *Aegiceras corniculatum-Avicennia marina* community. *Aegiceras corniculatum* often grew together to form a thicket up to 4 m tall. The data for this community were collected at Kooragang, Newcastle and in Iluka, NSW. The community at Kooragang was composed of the dominant *Aegiceras corniculatum* (3.5-4 m high) and occasional *Avicennia marina* (5-8 m high). The community at Iluka was an *Aegiceras* shrub together with salt-marsh herbaceous species: *Sesuvium portulacastrum* and *Suaeda australis*.

2. 4 *Avicennia marina-Excoecaria agallocha* community

Location: Mobbs Bay, Ballina, NSW
(Table 5, No. 6)

The data of the *Avicennia marina-Excoecaria agallocha* community were collected at Mobbs Bay, NSW.

Table 1 Phytosociological data of the mangrove vegetation at Kooragang Island, NSW.

Releve no.:	1	2	3	4
Filed no.:	K30	K31	K32	K33
Area of vegetation (m ²):	500	500	60	75
Height of tree layer (m):	14	15	8	9
Cover of tree layer (%):	70	80	80	80
Height of shrub layer (m):	10	9	3	5
Cover of shrub layer (%):	5	10	10	30
Height of herb layer (m):	0.5	0.5	0.3	0.5
Cover of herb layer (%):	3	15	20	5
Total no. of species:	1	1	2	2
<i>Avicennia marina</i>	T* 4.4	5.4	5.4	5.4
	S +	1.2	.	2.3
	H +	+	+2	+2
<i>Aegiceras corniculatum</i>	S .	.	1.2	+2
	H :	.	1.2	1.2

* T: Tree layer, S: Shrub layer, H: Herb layer

Date: 10 October, 1995

Location: Kooragang Island, Newcastle, NSW (32° 51'S, 151° 42-43'E)

Table 2 Phytosociological data of the mangrove vegetation at Fullerton Cove, NSW.

Releve no.:	1	2	3	4	5	6	7	8	9	10
Filed no.:	K34	K35	K36	K37	K38	K39	K40	K41	K42	K43
Area of vegetation (m ²):	100	120	140	120	49	150	64	50	30	30
Height of tree layer (m):	9	10	12	11	-	13	8	-	-	-
Cover of tree layer (%):	60	60	40	30	-	50	60	-	-	-
Height of shrub layer (m):	6	2	4	6	2	4	4	6	5	5
Cover of shrub layer (%):	5	5	5	5	95	10	15	80	60	30
Height of herb layer (m):	0.5	0.5	0.8	0.5	-	0.5	0.5	0.5	0.5	1
Cover of herb layer (%):	5	5	5	3	-	30	10	5	10	5
Total no. of species:	2	1	1	1	1	1	1	1	1	1
<i>Avicennia marina</i>	T* 4.4	4.4	3.3	3.3	.	3.3	4.4	.	.	.
	S +2	+	+	+	5.5	2.2	1.2	5.4	4.4	3.3
	H +	+	+	+	.	2.3	1.2	+	+2	+
<i>Suaeda australis</i>	H +	.	.	.	.	.	.	.	.	.

* T: Tree layer, S: Shrub layer, H: Herb layer

Date: 11 October, 1995, Location: Fullerton Cove, Newcastle, NSW (32° 52'S, 151° 45'E)

The *Avicennia marina-Excoecaria agallocha* community was a 6 m high forest with *Excoecaria agallocha* and *Avicennia marina*. The total number of species was five. Some of the component species were introduced from adjacent communities because the area of the community was not large. *Excoecaria agallocha* is mainly distributed on the landward edge of the mangroves.

2. 5 *Aegialitis annulata-Avicennia marina* community

Location: Yeppoon, Qld

(Table 6, Nos 7-8, 10-11)

Keppel Bay, Qld (Table 6, No. 9)

Kuramba, Qld (Table 11, Nos 1-5)

Table 3 Phytosociological data of the mangrove vegetation at Kooragang Island, NSW.

Releve no.:	1	2	3	4	5	6	7	8
Filed no.:	K44	K45	K49	K50	K48	K47	K46	K51
Area of vegetation (m ²):	50	50	65	40	36	25	80	50
Height of tree layer (m):	5	7	7	6	5	9	8	5
Cover of tree layer (%):	70	70	40	70	95	15	20	10
Height of shrub layer (m):	2	2	3	2	2.5	4	4	3.5
Cover of shrub layer (%):	15	10	40	20	60	95	90	95
Height of herb layer (m):	0.5	0.5	0.3	0.5	0.5	1.5	0.5	0.5
Cover of herb layer (%):	10	20	5	15	60	60	10	
Total no. of species:	2	2	3	2	2	2	2	2
<i>Avicennia marina</i>	T* 4.4	4.4	3.3	4.4	5.4	2.2	2.1	1.2
	S 1.2	1.2	1.2	+2	.	5.5	+2	+2
	H +	+2	1.2	.	.	.	.	.
<i>Aegiceras corniculatum</i>	S 1.2	+2	3.3	2.2	4.4	+2	5.5	5.5
	H +2	1.2	2.2	+	1.2	4.4	4.4	4.4
<i>Sporobolus virginicus</i>	H .	.	+2	.	.	.	.	.

* T: Tree layer, S: Shrub layer, H: Herb layer

Date: 12 October, 1995, Location: Kooragang Island, Newcastle, NSW (32° 52'S, 151° 45'E)

Table 4 Phytosociological data of the mangrove vegetation at Iluka, NSW.

Releve no.:	1	2	3	4	5
Filed no.:	K12	K13	K14	K15	K16
Area of vegetation (m ²):	48	32	90	100	12
Height of tree layer (m):	7	6	8	11	-
Cover of tree layer (%):	80	70	85	60	-
Height of shrub layer (m):	1.8	3	2	2	1.5
Cover of shrub layer (%):	10	20	20	15	70
Height of herb layer (m):	0.5	0.5	0.5	0.5	0.3
Cover of herb layer (%):	2	5	2	40	
Total no. of species:	1	2	3	4	4
<i>Avicennia marina</i>	T* 5.4	4.4	5.4	4.4	
	S 1.2	2.2	1.2	+	.
	H +	+	+	+	+2
<i>Aegiceras corniculatu</i>	S .	2.2	2.2	1.2	4.4
	H .	+	+	+	.
<i>Bruguiera gymnorrhiza</i>	T .	.	2.1	.	.
	S .	.	.	1.1	.
<i>Hibiscus tiliaceus</i>	S .	.	.	1.1	.
<i>Sesuvium portulacastrum</i>	H .	.	.	.	3.3
<i>Suaeda australis</i>	H .	.	.	.	1.2

* T: Tree layer, S: Shrub layer, H: Herb layer

Date: 16 September, 1995, Location: Iluka, NSW (29° 25'S, 153° 22'E)

Table 5 Phytosociological data of the mangrove vegetation at Mobbs Bay, NSW.

Releve no.:	1	2	3	4	5	6	
Filed no.:	K6	K7	K8	K9	K10	K11	
Area of vegetation (m ²):	24	32	50	60	60	80	
Height of tree layer (m):	7	7	8	8	7	9	
Cover of tree layer (%):	80	90	70	60	40	40	
Height of shrub layer (m):	3	3.5	3	2	3	3.5	
Cover of shrub layer (%):	30	60	15	10	15	10	
Height of herb layer (m):	0.5	0.5	0.5	-	0.5	0.5	
Cover of herb layer (%):	10	5	-	5	5		
Total no. of species:	2	2	3	3	3	5	
<i>Avicennia marina</i>	T*	5.4	5.5	4.4	4.4	3.3	3.3
	S	1.2	-	1.2	+	-	-
	H	-	1.2	+2	-	+	+
<i>Aegiceras corniculatum</i>	S	1.2	4.4	1.2	1.2	1.2	1.2
	H	+	+2	+	-	+2	+2
<i>Bruguiera gymnorhiza</i>	S	-	-	1.1	+	-	-
<i>Rhizophora stylosa</i>	S	-	-	-	-	-	+
<i>Excoecaria agallocha</i>	T	-	-	-	-	-	3.3
<i>Acrostichum speciosum</i>	H	-	-	-	-	-	+2
Juncaceae sp.	H	-	-	-	-	-	+

* T: Tree layer, S: Shrub layer, H: Herb layer

Date: 30 July 1995, Location: Ballina, NSW (28° 50'S, 153° 35'E)

Table 6 Phytosociological data of the mangrove vegetation at Yeppoon and Keppel Bay, Qld.

Releve no.:	1	2	3	4	5	6	7	8	9	10	11	
Filed no.:	K61	K75	K63	K68	K70	K64	K66	K67	K71	K65	K62	
Area of vegetation (m ²):	64	64	64	64	64	64	64	64	64	64	64	
Height of shrub layer (m):	4	4	6	5	7	3	4	5	4.5	6	5	
Cover of shrub layer (%):	80	70	95	70	40	95	95	90	80	90	80	
Height of herb layer (m):	1	0.5	1	1	0.5	1	0.5	1	1.2	1	1	
Cover of herb layer (%):	5	5	5	10	10	10	5	10	30	15	10	
Total no. of species:	2	2	2	3	4	5	3	3	4	4	4	
<i>Avicennia marina</i>	S*	5.4	4.4	5.5	4.4	3.3	5.5	5.5	5.5	5.4	5.4	5.4
	H	-	+2	-	-	+2	-	+	+2	-	+2	-
<i>Aegiceras corniculatum</i>	S	-	-	-	+	+2	-	-	-	-	-	-
	H	-	+	+2	1.2	-	+	+	+2	+2	1.2	-
<i>Aegialitis annulata</i>	H	-	-	-	-	-	+	+2	+	+	+	+2
<i>Ceriops tagal</i>	S	-	-	-	-	1.2	-	-	-	-	-	-
	H	+2	-	-	-	-	-	-	-	+2	-	+
<i>Rhizophora stylosa</i>	S	-	-	-	1.2	-	-	-	-	-	-	-
	H	-	-	-	-	-	+	-	-	-	+	-
<i>Bruguiera exaristata</i>	H	-	-	-	-	-	+2	-	-	1.2	-	+2
<i>Suaeda australis</i>	H	-	-	-	-	+2	-	-	-	-	-	-

* S: Shrub layer, H: Herb layer

Date: 30 October, 1995, Location: K61-68: Yeppoon, Qld (23° 10'S, 150° 45'E)
K70-71, K75: Keppel Bay, Qld (23° 20'S, 150° 55'E)

Table 7 Phytosociological data of the mangrove vegetation at Gladstone and Keppel Bay, Qld.

Releve no.:	1	2	3	4	5	6	7	8	
Filed no.:	K76	K59	K60	K58	K55	K56	K77	K79	
Area of vegetation (m ²):	30	64	64	64	30	64	64	64	
Height of shrub layer (m):	3.5	6.5	5	6	3	4	5	5	
Cover of shrub layer (%):	95	90	95	90	95	40	80	90	
Height of herb layer (m):	0.5	1	-	2	0.5	1.5	0.5	0.5	
Cover of herb layer (%):3	10	-	10	3	60	3	5		
Total no. of species:	2	1	1	2	2	2	3	2	
<i>Ceriops tagal</i>	S*	5.5	5.4	5.5	5.4	5.5	4.4	2.2	4.4
	H	+	+2	-	1.2	+	3.3	+	-
<i>Rhizophora stylosa</i>	S	-	-	-	-	2.2	-	-	-
	H	-	-	-	+2	2.3	-	-	-
<i>Bruguiera exaristata</i>	S	-	-	-	-	-	4.4	2.3	-
	H	-	-	-	-	-	-	+2	-
<i>Avicennia marina</i>	H	2.1	-	-	-	-	+2	-	-
<i>Suaeda australis</i>	H	-	-	-	+	-	-	-	-

* S: Shrub layer, H: Herb layer

Date: 27-30 October, 1995, Location: K55,K56,K58-60: Gladstone, Qld (23° 50'S, 151° 15'E)
K76,K77,K79: Keppel Bay, Qld (23° 20'S, 150° 55'E).

Table 8 Phytosociological data of the mangrove vegetation at Gladstone, Yeppoon and Keppel Bay, Qld.

Releve no.:	1	2	3	4	5	6	
Filed no.:	K57	K54	K69	K78	K82	K73	
Area of vegetation (m ²):	18	64	64	20	20	40	
Height of shrub layer (m):	2	4.5	3	3	2.5	5	
Cover of shrub layer (%):	70	95	80	85	95	85	
Height of herb layer (m):	0.5	-	0.5	-	1	1	
Cover of herb layer (%):5	-	20	-	5	10	-	
Total no. of species:	3	2	3	3	3	2	
<i>Lumnitzera racemosa</i>	S*	4.4	3.3	4.4	5.4	5.5	3.3
	H	-	-	-	-	-	+2
<i>Ceriops tagal</i>	S	2.2	3.3	2.2	1.1	5.5	-
	H	+	-	+2	-	+	-
<i>Avicennia marina</i>	S	-	-	-	+2	-	-
	H	-	-	+2	-	-	-
<i>Sporobolus virginicus</i>	H	-	-	-	-	+2	-
<i>Suaeda australis</i>	H	-	-	-	-	+	-
<i>Excoecaria agallocha</i>	S	-	-	-	-	-	4.3

* S: Shrub layer, H: Herb layer

Date: 27-30 October, 1995, Location: K54,K57: Gladstone, Qld (23° 50'S, 151° 15'E)
K69: Yeppoon, Qld (23° 10'S, 150° 45'E) and K73,K78,K82: Keppel Bay, Qld (23° 20'S, 150° 55'E).

Table 9 Phytosociological data of the mangrove vegetation at Gladstone and Keppel Bay, Qld.

Releve no.:	1	2	3
Filed no.:	K52	K53	K74
Area of vegetation (m ²):	64	64	64
Height of shrub layer (m):	4	4.5	5
Cover of shrub layer (%):	95	95	95
Height of herb layer (m):	1	1	1
Cover of herb layer (%):	5	3	3
Total no. of species:	1	1	2

<i>Rhizophora stylosa</i>	S*	5.5	5.5	5.4
	H	+	+2	-
<i>Aegiceras corniculatum</i>	H	.	.	+

* S: Shrub layer, H: Herb layer

Date: 28-30 Oct., 1995, Location: K52-53: Gladstone, Qld (23° 50'S, 151° 15'E)
K74: Keppel Bay, Qld (23° 20'S, 150° 55'E).

Table 10 Phytosociological data of the mangrove vegetation at Cape Ferguson, Qld.

Releve no.:	1	2	3	4	5
Filed no.:	K17	K18	K20	K19	K21
Area of vegetation (m ²):	56	48	32	50	12
Height of tree layer (m):	5	7	6	7	-
Cover of tree layer (%):	70	40	80	40	-
Height of shrub layer (m):	3	3	3	2.5	2
Cover of shrub layer (%):	30	30	30	30	30
Height of herb layer (m):	0.5	-	0.8	0.5	-
Cover of herb layer (%):	-	5	5	-	-
Total no. of species:	4	3	6	5	1

<i>Rhizophora stylosa</i>	T*	4.4	3.3	4.4	-	-
	S	1.2	+2	.	.	.
	H	+	.	.	+	.
<i>Avicennia marina</i>	T	1.2	.	.	3.3	.
	S	1.1	+	1.2	1.1	.
	H	-	-	-	-	-
<i>Osbornia octodonta</i>	S	1.2	2.2	2.2	+2	.
	H	+	.	.	.	.
<i>Ceriops tagal</i>	S	1.2	.	+	2.2	.
(? inc. <i>C. decandra</i>)	H	.	.	.	.	.
<i>Aegiceras corniculatum</i>	S	.	.	1.2	+	.
<i>Lumnitzera racemosa</i>	S	.	.	.	.	3.3
<i>Acrostichum speciosum</i>	H	.	.	+	.	.

* T: Tree layer, S: Shrub layer, H: Herb layer

Date: 7 September, 1995, Location: Cape Ferguson, Qld (19° 18'S, 147° 03'E)

Table 11. Phytosociological data of the mangrove vegetation at Kuramba, Qld.

Releve no.:		1	2	3	4	5
Filed no.:		K4	K3	K1	K5	K4
Area of vegetation (m ²):		15	18	15	12	21
Height of shrub layer (m):		4	5	6	6	7
Cover of shrub layer (%):		70	80	70	70	40
Height of herb layer (m):		1.2	0.5	0.5	0.5	1.2
Cover of herb layer (%):	50	30	10	15	70	
Total no. of species:		2	3	3	3	3
<i>Avicennia marina</i>	S*	4.4	5.4	4.4	4.4	3.3
	H	1.2	1.2	+	+	.
<i>Aegialitis annulata</i>	H	3.3	3.3	+2	1.2	4.4
<i>Batis argillicola</i>	H	-	+	+	+	+

* S: Shrub layer, H: Herb layer

Date: 20 June, 1995, Location: Kuramba, Qld (17° 25'S, 140° 50'E).

The *Aegialitis annulata-Avicennia marina* community was found at Yeppoon, Keppel Bay and Kuramba, Queensland. The *Aegialitis annulata-Avicennia marina* community was a two-layered community with tall *Avicennia* trees on the shrub layer and small *Aegialitis* shrubs on the herb layer. The ecological structure of the community was the same as the *Aegiceras corniculatum-Avicennia marina* community. The community had a 4-7 m high shrub layer and a 0.5-1.2m high herb layer. The shrub layer had a cover of 40-95% and the herb layer had a cover of 5-70%. *Aegialitis annulata*, called the club mangrove, grows to about 1.5-2 m in height and the base of the trunk is thickened making the plant look bottom-heavy and club-like.

2. 6 *Ceriops tagal* community

Location: Keppel Bay, Qld (Table 7, No. 1)
Gladstone, Qld (Table 7, Nos 2-6)

The *Ceriops tagal* community was found at Keppel Bay and Gladstone, Queensland. The community was from 3 to 6.5m high, had a cover of 40-95% and a total number of species of 1-2. The dominant species of the community was *Ceriops tagal*. The community was found towards the landward edge of mangrove vegetation. The areas of the community developed as a line 3-6 m wide along the river or coast and were not large at all. *Ceriops tagal* grew to 7-8 m high in the areas having some freshwater influence but often occurred as short, stunted trees in saline environ-

ments.

2. 7 *Ceriops tagal-Lumnitzera racemosa* community

Location: Gladstone, Qld (Table 8, Nos 1-2)
Yeppoon, Qld (Table 8, No. 3)
Keppel Bay, Qld (Table 8, Nos 4-5)

The data for the *Ceriops tagal-Lumnitzera racemosa* community were collected at Gladstone, Yeppoon and Keppel Bay in Queensland. The community was characterised by the dominant *Lumnitzera racemosa* and the common *Ceriops tagal*, which was from 2.5 to 5 m high and covered 70-95%. The total number of species varied from 2 to 3. *Lumnitzera racemosa*, called black mangrove, usually does not have above-ground roots. The southern limit of the distribution of the species is in Moreton Bay in southern Queensland.

2. 8 *Bruguiera exaristata-Ceriops tagal* community

Location: Keppel Bay, Qld (Table 7, Nos 7-8)

The data for this community were collected at Keppel Bay, Queensland. The community was characterised and differentiated by *Bruguiera exaristata* and *Ceriops tagal*, and had a height of 5 m and a cover of 80-90%. Total number of species was 2-3. The community was distributed on the inland side of the mangrove area. *Bruguiera exaristata* had smaller propagules with green caps and is distributed only

Table 12 Phytosociological data of the mangrove vegetation at Cairns Airport, Qld.

Releve no.:	1	2	3	4	5	6	7
Filed no.:	K23	K24	K25	K26	K27	K28	K29
Area of vegetation (m ²):	200	200	150	300	100	100	80
Height of tree-1 layer (m):	21	15	17	20	-	-	-
Cover of tree-1 layer (%):	90	95	70	80	-	-	-
Height of tree-2 layer (m):	12	-	-	12	8	8	7
Cover of tree-2 layer (%):	10	-	-	10	80	70	95
Height of shrub layer (m):	4	5	5	6	3	4	3.5
Cover of shrub layer (%):	10	20	15	10	10	20	40
Height of herb layer (m):	1	1	1	1	1	1	-
Cover of herb layer (%):	5	5	15	30	5	-	-
Total no. of species:	3	3	2	3	4	5	3
<i>Rhizophora apiculata</i>	T1* 4.4 T2 1.2 S +2 H +	5.4 . . . 2.2 +	2.2 . . . 1.2 +	. + . . . +2 . . . + . . .	. . . . . . . . . . . . .	. 1.1 . . . . . . . . . . .	. . . . . 1.2
<i>Rhizophora stylosa</i>	T1 2.2 T2 . S 1.2 H 1.2	1.1 . . . +2	4.4 . . . 1.2 . . . + . . .	5.4 1.2 . . . 1.2 . . . + . . .	. . . . . + . . . + . . .	. 2.2 . . . 2.2 . . .. . . .	.. . . .. . . .. . . .
<i>Bruguiera parviflora</i>	T2 . S .	. . . . . .	. . . . . .	. . . . . .	4.4 1.1	3.3. . .	.. . .
<i>Bruguiera gymnorhiza</i>	T2 + S .	. . . . . .	. . . . . .	. . . . . .	. . . 2.3	. . .. . .	. . .. . .
<i>Avicennia marina</i>	T2 . S . H .	. . . 1.1 . . . . . .	. . . . . . . . .	. . . . . . . . .	3.3 2.3 +	. . . . . . . . .	2.2 1.2 . . .
<i>Rhizophora mucronata</i>	S .	. . .	. . .	1.2 . . .	. . .	. . .	. . .
<i>Cerops tagal</i>	T2 . S .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	2.2 1.2	. . .. . .
<i>Aegiceras corniculatum</i>	H .	. . .	. . .	. . .	. . .	+	. . .
<i>Sonneratia alba</i>	T2 .	. . .	. . .	. . .	. . .	. . .	4.4

* T1: Tree-1 layer, T2: Tree-2 layer, S: Shrub layer, H: Herb layer

Date: 11 September, 1995, Location: Cairns Airport, Qld. (16° 53'S, 145° 43'E)

on the northern coasts of Australia from Gladstone northwards.

2.9 *Lumnitzera racemosa-Excoecaria agallocha* community

Location: Keppel Bay, Qld (Table 8, No. 6)

The *Lumnitzera racemosa-Excoecaria agallocha* community was 8 m high and was dominated by *Lumnitzera racemosa* and *Excoecaria agallocha*. The data were collected on Keppel Bay, Queensland. The habitat of the community was on the most inland side of the mangroves at Keppel Bay. *Excoecaria*

agallocha, called milky mangrove, can grow up to 15 m tall.

2.10 *Rhizophora stylosa* community

Location: Gladstone, Qld (Table 9, Nos 1-2)
Keppel Bay, Qld (Table 9, No. 3)

The *Rhizophora stylosa* community was 4-5 m high, covered 95% and was composed of *Rhizophora stylosa* only. The data for this community were collected at Gladstone and Keppel Bay, Queensland. Total number of species of the community was 1-2. The community was a *Rhizophora*-dominated man-

Table 13 Phytosociological data of the mangrove vegetation at Mossman, Qld

Releve no.: 1, Filed no.: K22, Area of vegetation: 200 m ²	
Height & Cover:	Tree-1 layer(T1): 22m, 90%
	Tree-2 layer(T2): 14m, 10%
	Shrub layer(S): 4m, 10%
	Herb layer(H): 0.3m, 30%
<u>Total no. of species: 3</u>	
<i>Bruguiera parviflora</i>	T1-4.4, H-3.3
<i>Bruguiera gymnorhiza</i>	T1-3.3, T2-1.2
<i>Rhizophora mucronata</i>	S-+2, H-+

Date: 10 September, 1995, Location: Mossman, Qld (16° 25'S, 145° 20'E)

grove forest typical.

2.11 *Osbornia octodonta*-*Rhizophora stylosa* community

Location: Cape Ferguson, Qld
(Table 10, Nos 1-3)

The *Osbornia octodonta*-*Rhizophora stylosa* community was from 5 to 7 m high, and the total number of species varied from 3 to 6. The community was characterised by dominating *Rhizophora stylosa* and 2-3 m high shrubs of *Osbornia octodonta*. *Osbornia octodonta* belongs to the same family as the *Eucalyptus* (Myrtaceae) with its crushed leaves having the same distinctive smell.

2.12 *Osbornia octodonta*-*Avicennia marina* community

Location: Cape Ferguson, Qld
(Table 10, No. 4)

The *Osbornia octodonta*-*Avicennia marina* community was a 7 m high forest dominated by *Avicennia marina* with *Osbornia octodonta* shrubs. The data for the community were collected at Cape Ferguson, Qld. The community was typical of *Avicennia marina*-dominated forests in northern Australia.

2.13 *Lumnitzera racemosa* community

Location: Cape Ferguson, Qld
(Table 10, No. 5)

The *Lumnitzera racemosa* community, dominated by *Lumnitzera racemosa*, occurs on the inland side of the mangrove areas. The data for the community

were collected at Cape Ferguson, Qld. The community had a height of 2 m and a cover of 30%. The habitat of the *Lumnitzera racemosa* trees was similar to that of *Excoecaria agallocha* and *Ceriops tagal*. Sometimes, these three species form mixed stands.

2.14 *Rhizophora stylosa*-*Rhizophora apiculata* community

Location: Cairns, Qld (Table 12, Nos 1-4)

The *Rhizophora stylosa*-*Rhizophora apiculata* community comprised a tall tree vegetation, having a height of 15-21 m and a cover of 70-95%. The community was dominated and characterised by two *Rhizophora* species: *Rhizophora apiculata* and *Rhizophora stylosa*. The total number of species was from 2 to 3 and the cover of shrub and herb layers was less than 20%. *Rhizophora* species were trees with stilt- or prop-type above-ground roots.

2.15 *Rhizophora stylosa*-*Bruguiera parviflora* community

Location: Cairns, Qld (Table 12, Nos 5-6)

The *Rhizophora stylosa*-*Bruguiera parviflora* community was 8 m high and the total number of species was from 4 to 5. The data for this community were collected in Cairns, Qld.

2.16 *Avicennia marina*-*Sonneratia alba* community

Location: Cairns, Qld (Table 12, No. 7)

The data for the *Avicennia marina*-*Sonneratia alba* community were collected at Cairns. The community

Table 14 Mean temperature on the east coast of Australia and southern Japan.

Month (Japan)	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Latitude	Longitude
Month (Australia)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.		
Naha/J	28	28	27	24	21	18	16	16	18	21	24	26	26° 11' N	127° 41' E
Amami-Oshima/J	28	28	27	23	20	16	14	15	17	20	23	26	28° 23' N	129° 30' E
Kagoshima/J	27	28	25	20	14	9	7	8	11	16	20	23	31° 36' N	130° 33' E
Muroto/J	25	26	24	19	15	10	7	8	10	15	18	21	33° 15' N	134° 11' E
Ashizuri/J	26	27	25	20	16	11	8	9	12	17	20	23	32° 44' N	133° 00' E
Shiono/J	25	27	24	19	15	10	8	8	11	15	19	22	33° 25' N	130° 33' E
Cairns/A	28	28	27	25	23	22	21	21	23	25	26	27	16° 55' S	145° 45' E
Townsville/A	28	27	27	25	23	21	20	21	23	25	26	27	19° 14' S	146° 50' E
Rockhampton/A	28	28	26	24	20	18	17	18	21	24	26	27	23° 20' S	150° 30' E
Brisbane/A	25	25	24	21	18	16	15	16	18	21	23	24	27° 30' S	153° 00' E
Newcastle/A	22	22	21	19	16	13	13	14	16	18	20	21	32° 55' S	151° 45' E
Sydney/A	22	22	21	18	15	13	12	13	16	18	20	21	33° 51' S	151° 10' E
Melbourne/A	20	20	18	15	13	10	10	11	13	15	16	19	37° 50' S	145° 00' E
Wilson's/A	17	18	17	15	13	11	10	11	12	13	14	16	39° 00' S	146° 50' E

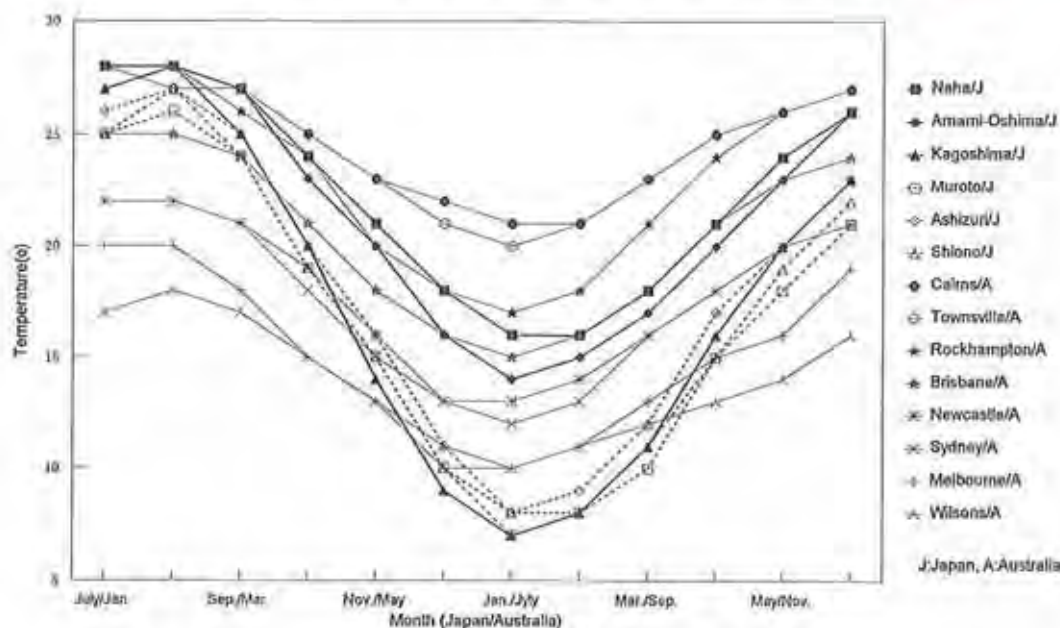


Figure 1 Mean monthly temperature.

had a height of 7 m and a cover of 95% in tree layer and 40% in shrub and herb layer. Total number of species was three and *Sonneratia alba* was the dominant species. The habitat was on the river-side front of the mangroves near Cairns Airport.

2.17 *Bruguiera gymnorrhiza*-*Bruguiera parviflora* community

Location: Mossman, Qld (Table 13, No. 1)

The *Bruguiera gymnorrhiza*-*Bruguiera parviflora* community comprised a tall tree vegetation, having a height of 22 m and a cover of 90%. The community was dominated and characterised by two *Bruguiera* species: *Bruguiera gymnorrhiza* and *Bruguiera parviflora*. The total number of species was three and the

cover of tree-2 and shrub layers was 10%. *Bruguiera* species have buttresses at the base of the trunk and knee roots. They can grow to 25m tall.

Latitudinal limits in Australia and East Asia (Japan)

Approximately 40 mangrove species, belonging to 14-15 families, occur in Australia. None of the species are endemic. The flora as a whole is related to the mangrove flora of South-East Asia, with most of the genera and some of the species extending to the east coast of Africa and the Red Sea (Beadle 1981). *Osbornia octodonta* is listed as endemic to Australia by Macnae (1966) but (very rarely) occurs as far north as the Philippines. The biogeographic distribution of mangrove species in Australia has been described by

Lear and Turner (1977), Saenger et al. (1977), Semeniuk et al. (1978, Western Australia), Wells (1983) and Hutchings and Saenger (1987). The limits are preceded by a gradual attenuation of species with increasing latitudes, with the largest number of species occurring on the northern and north-eastern coastlines, where most of the 39 (Duke 1992) mangrove species are recorded. This concentration can be attributed to the high temperature and rainfall of the tropical climate.

The latitudinal limits of mangroves in Australia and East Asia are as follows:

Western Australia Southern limit: 33°16'S

Eastern Australia Southern limit: 38°45'S

East Asia (Japan) Northern limit: 31°21'N

East Asia (China) Northern limit: c. 26°N

The *Kandelia candel* community in the Zhejiang Province (27°31'N) of China is the northernmost mangrove but it was transplanted in 1958 (Peng 1987).

Mangrove vegetation grows in a particular kind of rather unstable, difficult environment. Walsh (1974) identified five characteristics as essential mangrove prerequisites on a global scale, and Chapman (1975, 1977) added two others. They are (1) air temperature within a certain range, (2) mud substrate, (3) protection, (4) salt water, (5) tidal range, (6) ocean current and (7) shallow shores. Saenger and Moverley (1985) suggested that, in the presence of an adequate rainfall, temperature is the major factor in reducing species abundance with latitude.

Distribution of mangroves and mean temperature

Walsh (1974) and Chapman (1975, 1977) maintained that extensive mangrove development occurs only when the average air temperature of the coldest month is higher than 20°C and where the seasonal range does not exceed 10 degrees. Also, the distribution of mangroves appears to correlate reasonably well with the 16°C isotherm for the mean temperature of the coldest month (Chapman 1977). However, Barth (1981) maintained that the presence of mangroves correlates with those areas where the water temperature of the warmest month exceeds 24°C, and the limits occur in those waters that never exceed 24°C throughout the year.

Avicennia marina grows in the Abrolhos Islands off Western Australia and Barwon Heads, Port Phillip Bay, Westernport Bay and Corner Inlet in Victoria,

where the daily mean minimum temperature drops to 4°C and 7°C in July (Melbourne and Adelaide respectively), and where minimum temperatures of 0°C have been recorded (Macnae 1966). Hutchings and Saenger (1987) stated that, once established, *Avicennia* can withstand low but not sub-zero temperatures. The occurrence of mangrove fossils in south-western Australia (Churchill 1973) suggests that the current mangrove vegetation on the southern Australian coastline is a relict of earlier warmer conditions which has managed to maintain itself in a few favourable localities.

In Japan, there are quite similar mean temperatures in the five locations: Kagoshima (Kiire), Muroto, Ashizuri and Shiono (table 14, figure 1). However, there is no mangrove vegetation, except in Kagoshima (Kiire). This suggests that *Kandelia candel* in Kiire may be a relict from an earlier time or may have been transplanted from the southern islands more than a few hundred years ago.

Kiire, Kagoshima, the northern limit of Japanese mangroves, is located at 31° North. Newcastle, Sydney, Melbourne and Wilsons Promontory in south-eastern Australia are all located more than 32° South. Japan has higher mean temperatures than south-eastern Australia during the summer months (June-September in Japan and December-March in Australia) but south-eastern Australia has higher mean temperatures during the winter (December-March in Japan and June-September in Australia). Therefore, one of the factors limiting mangrove distribution may well be the temperature during winter.

Biodiversity of mangrove species: Latitudinal comparison of distribution of mangrove species

Figure 2 shows the latitudinal distribution of the main mangrove species in Australia and East Asia. The upper two lines of each species show data from the east and west coasts of Australia. The lower two lines show data from China and Japan. For example, *Avicennia marina* develops up until 33-36° S (in detail 33°00'S to 36°59'S) on the west coast of Australia, 37-40° South on the east coast of Australia, and up until 29-32° North in China and Taiwan and 26-28° North in Japan.

Some biogeographic characteristics were identified from the data collected: (1) Most mangrove species developed in both areas having similar longitude. (2) Many mangrove species in the southern

hemisphere developed at higher latitudes than in the northern hemisphere. (3) Only a few mangrove species such as *Acanthus ebracteatus* and *Nypa fruticans* developed at higher latitudes in the northern hemisphere than in the southern hemisphere. (4) The east coast of Australia was richer in species than the west coast. Most of the main mangrove species developed to a more southerly latitude on the east coast of Australia than on the east coast. *Avicennia marina*, *Excoecaria agallocha*, *Rhizophora stylosa* and *Lumnitzera racemosa* are examples. (5) *Kandelia candel*, which developed in both South-East and East Asia, is not distributed in Australia. (6) *Osbornia octodonta*,

Bruguiera exaristata, *Xylocarpus australasicus* etc., which occur in Australia, are not found in East Asia. However, *Osbornia octodonta* is occurs in the Philippines.

These ecological or biogeographical characteristics may be result of topographical and geographical factors and human activities. Most of the coastal areas in China were developed in earlier times and have become artificial coastlines without mangroves or other vegetation. Except for Kiire in Kyushu, mangroves in Japan developed only in the small southern islands. The isolation of the mangrove vegetation on the small islands in the south might have limited its

Table 15 Classification of mangrove vegetation in Japan by dominant species.

(a) <i>Kandelia candel</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
4	Kiire (Kyushu)	31	130	<i>Kandelia candel</i>	3	2.5-5	70-95	1-4	4.4-5.5	<i>Phragmites australis</i>	1.2
2	Tanegashima Is.	30	130	<i>Kandelia candel</i>	7	1-2.5	40-95	1-2	3.2-5.5		
3	Yakushima Is.	30	130	<i>Kandelia candel</i>	3	3-3.5	90	7-11	3.2-5.5		
13	Amami Oshima	28	129	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	6	2-5	50-90	2-4	4.3-5.4	<i>Bru. gymnorrhiza</i>	1.1-2.3
30	Amami Oshima	28	129	<i>Kandelia candel</i>	3	2.5-4.5	85-90	2	4.4-5.5	<i>Bru. gymnorrhiza</i>	+1.2
15	Okinawa Island	26	127-8	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	5	1-3	75-90	1	4.4-5.5		
16	Okinawa Island	26	127-8	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	6	2-5	80-85	2-3	3.3-5.4	<i>Bru. gymnorrhiza</i>	2.2-3.3
18	Iriomote Island	24	123	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	3	4-5	80-90	3	3.2-5.4	<i>Bru. gymnorrhiza</i>	1.2-4.4
35	Iriomote Island	24	123	<i>Rhizophora stylosa</i>	3	3-5	70-90	2	3.2-5.5	<i>Rhizophora stylosa</i>	1.1
36	Iriomote Island	24	123	<i>Kandelia candel</i>	1	1.5-2.5	60	1	4.3-4.4		
28	Iriomote Island	24	123	<i>Kandelia candel</i>	2	2.5-3.5	60-80	1	4.3-5.4		
29	Irabu Island	24	123	<i>Kandelia candel</i>	1	3	80	1	5.5		
31	Iriomote Island	24	123	<i>Kandelia candel</i>	4	2.5-6	60-70	2-3	3.3-4.4	<i>Rhizophora stylosa</i>	1.1-2.2
(b) <i>Bruguiera gymnorrhiza</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
12	Amami Oshima	28	129	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	3	1.3-4	70-80	2-6	3.3-4.4	<i>Kandelia candel</i>	2.2-4.4
14	Okinawa Island	26	127-8	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	2	3-4	60-70	2-3	4.4	<i>Kandelia candel</i>	+1.2
20	Okinawa Island	26	127-8	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	3	3-4	80-90	2-3	4.4	<i>Kandelia candel</i>	3.3-5.5
7	Iriomote Island	24	123	<i>Rhizophora stylosa</i>	8	4-6	70-90	2	4.4-5.4	<i>Rhizophora stylosa</i>	+2.3
19	Iriomote Island	24	123	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	5	4-5	70-90	2-4	4.4-5.5	<i>Excoecaria agallocha</i>	1.1-1.2
10	Iriomote Island	24	123	<i>Sonneratia alba</i> - <i>Lumnitzera racemosa</i>	3	3	60-70	3-4	3.2-4.4	<i>Rhizophora stylosa</i>	+2.1-2
21	Iriomote Island	24	123	<i>Bruguiera gymnorrhiza</i>	14	5-10	70-95	2-4	4.3-5.4	<i>Rhizophora stylosa</i>	1.1-2.3
22	Iriomote Island	24	123	<i>Bruguiera gymnorrhiza</i>	10	6-9	90-95	1	5.5		
23	Iriomote Island	24	123	<i>Bruguiera gymnorrhiza</i>	4	5-8	70-90	4-8	3.3-5.4	<i>Pandanus odoratissimus</i>	1.2-2.2
40	Iriomote Island	24	123	<i>Rhizophora stylosa</i> - <i>B. gymnorrhiza</i>	2	4	80	3-5	4.3-4.4	<i>Acrostichum aureum</i>	1.2-3.4
(c) <i>Sonneratia alba</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
9	Iriomote Island	24	123	<i>Sonneratia alba</i> - <i>Lumnitzera racemosa</i>	7	2-6	70-85	1-3	3.2-5.4	<i>Rhizophora stylosa</i>	1.1-3.3
27	Iriomote Island	24	123	<i>Sonneratia alba</i>	5	3.8-8	40-80	2-4	2.2-5.5	<i>Avicennia marina</i>	+2.3-3
32	Iriomote Island	24	123	<i>Sonneratia alba</i>	3	3-4	70-80	1	4.4-5.4		
33	Iriomote Island	24	123	<i>Sonneratia alba</i>	12	4-5	70-80	2-4	4.3-5.4	<i>Rhizophora stylosa</i>	+2.2
39	Iriomote Island	24	123	<i>Avicennia marina</i>	7	4-6	60-80	4-5	4.4-5.4	<i>Avicennia marina</i>	+2.2
(d) <i>Rhizophora stylosa</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
6	Ishigaki Island	24	124	<i>Rhizophora stylosa</i>	2	3-4	40-95	1-2	3.3-5.5	<i>Bru. gymnorrhiza</i>	+2
8	Iriomote Island	24	123	<i>Rhizophora stylosa</i>	7	3-6	70-90	2	3.2-5.5	<i>Bru. gymnorrhiza</i>	1.1-3.3
24	Iriomote Island	24	123	<i>Rhizophora stylosa</i>	4	2.8-3.5	30-85	1-2	3.2-5.5		
25	Iriomote Island	24	123	<i>Rhizophora stylosa</i>	7	6-7	80-90	2-3	4.4-5.5	<i>Bru. gymnorrhiza</i>	+3.2
34	Iriomote Island	24	123	<i>Rhizophora stylosa</i>	1	2-5	40-90	1	3.4-5.5		
(e) <i>Avicennia marina</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
5	Obama Island	24	123	<i>Avicennia marina</i>	2	1-1.5	90	2-3	5.4	<i>Rhizophora stylosa</i>	1.2-2.2
26	Iriomote Island	24	123	<i>Avicennia marina</i>	3	2-2.5	90	3-4	5.4	<i>Sonneratia alba</i>	1.2-2.3
38	Iriomote Island	24	123	<i>Avicennia marina</i>	5	1.2-2.5	60-95	2	3.3-5.5	<i>Rhizophora stylosa</i>	1.2-3.3
(f) <i>Lumnitzera racemosa</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
11	Iriomote Island	24	123	<i>Sonneratia alba</i> - <i>Lumnitzera racemosa</i>	5	2-5	80-85	2	3.4-5.4	<i>Bru. gymnorrhiza</i>	+1.2
37	Iriomote Island	24	123	<i>Lumnitzera racemosa</i>	7	2-5	70-90	2-5	4.4-5.5	<i>Bru. gymnorrhiza</i>	1.1-2.2
(g) <i>Myoporum hontiooides</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
1	Tanegashima Is.	30	130	<i>Kandelia candel</i>	3	1.3-2	85-100	2-3	2.2-5.4	<i>Kandelia candel</i>	2.2-4.4
(h) <i>Excoecaria agallocha</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp. #	CD1	2nd dominant species	CD2
17	Ishigaki Island	24	124	<i>Bruguiera gymnorrhiza</i> - <i>Kandelia candel</i>	2	3-4	90	3-6	2.2-3.3	<i>Kandelia candel</i>	2.3-4.3

#: No. of releve(s), H (m): Height of vegetation (m), Cover (%): Cover of vegetation (%), Sp. #: No. of component species.

CD1: Cover degree of dominant species, CD2: Cover degree of 2nd dominant species

Data: 1-3: Suzuki 1980, 4: Suzuki 1981, 5-20: Suzuki 1979, 21-31: Suzuki 1989, 32-40: Miyawaki, Suzuki et al. 1982.

expansion to areas farther north.

List and classification of mangrove vegetation in Australia and Japan

Many studies of mangrove vegetation in Japan are already available and can provide important background information. Table 15 shows the list of the Japanese mangrove vegetation which has been reported from a phytosociological viewpoint (Miyawaki, Suzuki et al. 1982, Nakamura 1989, Suzuki 1979, 1980, 1981 et al.). Phytosociological data list of Japan for each type of mangrove community, that is each dominant species, and each publication (table 15) is listed together with the investigated areas (location name) with latitudinal and longitudinal data, the names of communities, height and cover of vegetation, total number of component species, primary and secondary dominant species, their cover degrees and their sociabilities.

Mangrove vegetation in Japan were categorised by dominant species as the following 8 types of vegetation:

- (a) *Kandelia candel*-dominated vegetation
(Height of vegetation: 1-6 m)
- (b) *Bruguiera gymnorrhiza*-dominated vegetation
(Height of Vegetation: 1.5-10m)
- (c) *Sonneratia alba*-dominated vegetation
(Height of vegetation: 2-8 m)
- (d) *Rhizophora stylosa*-dominated vegetation
(Height of vegetation: 2.8-7 m)
- (e) *Avicennia marina*-dominated vegetation
(Height of vegetation: 1-2, 5m)
- (f) *Lumnitzera racemosa*-dominated vegetation
(Height of vegetation: 2-5 m)
- (g) *Myrsine bontiodoides*-dominated vegetation
(Height of vegetation: 1.3-2 m)
- (h) *Excoecaria agallocha*-dominated vegetation
(Height of vegetation: 3-4 m)

Except for Bridgewater (1985), phytosociological studies of mangrove vegetation in Australia have not previously been done. In this paper, Australian mangrove vegetation has been listed using data from Bridgewater (1985), Davie (1987), Saenger (1983) and Saenger (1995, unpublished) as well as original data (tables 1-13). However, the phytosociological data lists (tables 1-13, 16) do not cover all over community types of Australian mangroves. This paper is the first report of a series of phytosociolog-

ical studies on Australian mangrove vegetation. Phytosociological data list of Australia for each type of mangrove community, that is each dominant species, and each publication (table 16) is listed together with the investigated areas (location name) with latitudinal and longitudinal data, the names of communities, height and cover of vegetation, total number of component species, primary and secondary dominant species, and their cover degrees.

Mangrove vegetation in Australia were categorised by dominant species as the following 13 types of vegetation:

- (a) *Avicennia marina*-dominated vegetation
(Height of vegetation: 0.5-14 m)
- (b) *Ceriops tagal*-dominated vegetation
(Height of vegetation: 0.9-6.5 m)
- (c) *Rhizophora stylosa*-dominated vegetation
(Height of vegetation: 2.6-21 m)
- (d) *Excoecaria agallocha*-dominated vegetation
(Height of vegetation: 5-9 m)
- (e) *Sonneratia alba*-dominated vegetation
(Height of vegetation: 5.8-8.1 m)
- (f) *Xylocarpus australasicus*-dominated vegetation
- (g) *Lumnitzera racemosa*-dominated vegetation
(Height of vegetation: 2-4, 5m)
- (h) *Bruguiera exaristata*-dominated vegetation
- (i) *Camptostemon schultzei*-dominated vegetation
- (j) *Rhizophora lamarcki*-dominated vegetation
(Height of vegetation: 4.4-5.3 m)
- (k) *Aegiceras corniculatum*-dominated vegetation
(Height of vegetation: 1.5-8 m)
- (l) *Aegialitis annulata*-dominated vegetation
(Height of vegetation: 0.6-0.8 m)
- (m) *Bruguiera parviflora*-dominated vegetation
(Height of vegetation: 8-22 m)

Discussion

In this paper, original phytosociological data from 80 stands in New South Wales and Queensland, Australia, have been reported. The number of stands researched was not enough to analyse and classify Australian mangrove vegetation from a phytosociological viewpoint. However, the preliminary analysis, using the original and other data, indicates that Australian mangrove vegetation could be categorised into the same types of phytosociological communities as those of Japan and South-East Asia.

Australian mangrove vegetation originally developed in relation to neighbouring areas such as New

Table 16 Classification of mangrove vegetation in Australia by dominant species.

(a) <i>Avicennia marina</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
86	Westport Bay, Vic.	38	145	<i>Avicennia marina</i> shrubland	-	1-2	50-70	1	4		
98	Newcastle, NSW	32	151	<i>Aegialitis annulata</i> - <i>Avicennia marina</i>	10	5-14	40-95	1-3	3-5	<i>Aegiceras corniculatum</i>	1-4
100	Newcastle, NSW	32	151	<i>Avicennia marina</i>	10	2-13	30-95	1-2	3-5		
87	Iluka, NSW	29	153	<i>Aegiceras corniculatum</i> - <i>Avi. marina</i>	3	6-11	60-85	1-4	4-5	<i>Aegiceras corniculatum</i>	1-2
97	Iluka, NSW	29	153	<i>Avicennia marina</i>	1	7	80	1	5		
1	Ballina, NSW	28	153	<i>Aegiceras corniculatum</i> - <i>Avi. marina</i>	5	7-8	40-90	2-3	3-5	<i>Aegiceras corniculatum</i>	1.2-4.4
101	Yeppoon, Qld	23	150	<i>Avicennia marina</i>	1	4	80	2	5		
102	Yeppoon, Qld	23	150	<i>Aegiceras corniculatum</i> - <i>Avi. marina</i>	3	3-6	70-95	2-5	4-5	<i>Aegiceras corniculatum</i>	+1
103	Keppel Bay, Qld	23	150	<i>Aegiceras corniculatum</i> - <i>Avi. marina</i>	2	4-7	40-70	2-4	3-4	<i>Ceriops tagal</i>	1
104	Yeppoon, Qld	23	150	<i>Aegialitis annulata</i> - <i>Avicennia marina</i>	4	4-6	80-95	3-4	5	<i>Aegiceras corniculatum</i>	+1
105	Keppel Bay, Qld	23	150	<i>Aegialitis annulata</i> - <i>Avicennia marina</i>	1	4.5	80	4	5	<i>Bruguiera exaristata</i>	1
54	Port Hedland, W.A.	20	118	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	1	-	-	2	4	<i>Suaeda arbusculoides</i>	3
38	King Bay, W.A.	20	116	<i>Bruguiera exaristata</i> - <i>Ceriops tagal</i>	1	-	-	3	3	<i>Bruguiera exaristata</i>	2
75	Bowen, Qld	20	148	<i>Avicennia marina</i>	1	0.5	-	2	-	<i>Rhizophora stylosa</i>	-
84	Bowen, Qld	20	148	<i>Aegialitis annulata</i> - <i>Avicennia marina</i>	4	0.5-0.8	-	2-3	-	<i>Aegialitis annulata</i>	-
85	Bowen, Qld	20	148	<i>Rhizophora stylosa</i> - <i>Avicennia marina</i>	3	1.6-4.1	-	4-5	-	<i>Rhizophora stylosa</i>	-
90	Cape Ferguson, Qld	19	147	<i>Osbornia octodonta</i> - <i>Avicennia marina</i>	1	7	40	5	3	<i>Ceriops tagal</i>	2
73	Kuramba, Qld	17	140	<i>Aegialitis annulata</i> - <i>Avicennia marina</i>	5	4-7	40-80	2-3	3-5	<i>Aegialitis annulata</i>	+4
20	near Derby, W.A.	17	123	<i>Avi. marina</i> - <i>Campostemon schultzei</i>	1	-	-	1	3	<i>Suaeda arbusculoides</i>	4
55	near Derby, W.A.	17	123	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	3	-	-	2-3	2-4	<i>Suaeda arbusculoides</i>	3-4
59	near Carby, W.A.	17	123	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	1	-	-	5	3	<i>Aegialitis annulata</i>	3
15	Barred Creek, W.A.	17	122	<i>Avi. marina</i> - <i>Campostemon schultzei</i>	1	-	-	2	4	<i>Campostemon schultzei</i>	2
19	Fisherman's Bend, W.A.	17	122	<i>Avi. marina</i> - <i>Campostemon schultzei</i>	2	-	-	3-5	3	<i>Campostemon schultzei</i>	3
23	Willie Creek, W.A.	17	122	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	2	-	-	3	3	<i>Campostemon schultzei</i>	3
49	Barred Creek, W.A.	17	122	<i>Avicennia marina</i> - <i>Aegialitis annulata</i>	1	-	-	2	4	<i>Aegialitis annulata</i>	3
56	Willie Creek, W.A.	17	122	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	1	-	-	2	4	<i>Suaeda arbusculoides</i>	3
62	Willie Creek, W.A.	17	122	<i>Avicennia marina</i> - <i>Batis argillicola</i>	1	-	-	3	5	<i>Batis argillicola</i>	2
63	Broome township, W.A.	17	122	<i>Avicennia marina</i> - <i>Batis argillicola</i>	1	-	-	2	3	<i>Batis argillicola</i>	3
17	Russell & Fairfax Is., W	15	128	<i>Avi. marina</i> - <i>Campostemon schultzei</i>	2	-	-	2	2-3	<i>Campostemon schultzei</i>	2-3
22	Stall Bay, W.A.	15	128	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	1	-	-	1	3	<i>Ceriops tagal</i>	2
50	Parrys Creek, W.A.	15	128	<i>Avicennia marina</i> - <i>Aegialitis annulata</i>	4	-	-	2	3-5	<i>Aegialitis annulata</i>	2-3
60	Parrys Creek, W.A.	15	128	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	1	-	-	3	4	<i>Suaeda arbusculoides</i>	4
65	Russell Island et al., W.A.	15	128	<i>Avicennia marina</i> - <i>Batis argillicola</i>	5	-	-	4-6	2-3	<i>Halosarcia indica</i>	2-4
127	Domette Point, WA	15	128	<i>Aegialitis annulata</i> - <i>Avicennia marina</i>	1	1.5	-	3	-	<i>Aegialitis annulata</i>	-
130	Lacrosse Island, WA	15	128	<i>Avicennia marina</i>	1	6.3	-	1	-		
51	Anson Bay, N.T.	13	130	<i>Excoecaria agal.</i> - <i>Sporobolus virginicus</i>	1	-	-	5	3	<i>Sporobolus virginicus</i>	3
58	Anson Bay, N.T.	13	130	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	1	-	-	4	3	<i>Aegialitis annulata</i>	3
64	Anson Bay, N.T.	13	130	<i>Avicennia marina</i> - <i>Batis argillicola</i>	1	-	-	4	3	<i>Aegialitis annulata</i>	3
57	Darwin Harbour, N.T.	12	130	<i>Avicennia marina</i> - <i>Suaeda arbusculoides</i>	1	-	-	4	3	<i>Suaeda arbusculoides</i>	4

(b) <i>Ceriops tagal</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
107	Gladstone, Qld	23	151	<i>Ceriops tagal</i>	5	3-6.5	60-95	1-2	4-5	<i>Rhizophora stylosa</i>	2
106	Keppel Bay, Qld	23	150	<i>Ceriops tagal</i>	1	3.5	95	2	5	<i>Avicennia marina</i>	2
111	Keppel Bay, Qld	23	150	<i>Bruguiera exaristata</i> - <i>Ceriops tagal</i>	2	5	80-90	2-3	2-4	<i>Bruguiera exaristata</i>	2-4
74	Bowen, Qld	20	148	<i>Ceriops tagal</i>	6	0.9-4.8	-	1	-		
76	Bowen, Qld	20	148	<i>Avicennia marina</i> - <i>Ceriops tagal</i>	3	4.1-6.2	-	2-3	-	<i>Avicennia marina</i>	-
77	Bowen, Qld	20	148	<i>Lumnitzera racemosa</i> - <i>Ceriops tagal</i>	2	-	-	2	-	<i>Lumnitzera racemosa</i>	-
24	Barred Creek etc., W.A.	17	122	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	3	-	-	4	3	<i>Campostemon schultzei</i>	2-3
42	Barred Creek, W.A.	17	122	<i>Avicennia marina</i> - <i>Ceriops tagal</i>	2	-	-	4-5	3	<i>Osbornia octodonta</i>	3
43	Willie Creek, W.A.	17	122	<i>Excoecaria agallocha</i>	3	-	-	2-3	3-4	<i>Excoecaria agallocha</i>	3
27	Still Bay etc., W.A.	15	128	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	3	-	-	4-5	2-3	<i>Campostemon schultzei</i>	2-3
29	Still Bay, W.A.	15	128	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	1	-	-	4	4	<i>Xylocarpus australasicus</i>	2
45	Still Bay, W.A.	15	128	<i>Excoecaria agallocha</i>	1	-	-	2	4	<i>Excoecaria agallocha</i>	2
47	Russell Island, W.A.	15	128	<i>Excoecaria agallocha</i>	1	-	-	5	3	<i>Excoecaria agallocha</i>	2
25	Anson Bay, N.T.	13	130	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	2	-	-	4-5	2-3	<i>Rhizophora stylosa</i>	2-3
26	Anson Bay, N.T.	13	130	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	1	-	-	4	3	<i>Campostemon schultzei</i>	3
37	Anson Bay, N.T.	13	130	<i>Bruguiera exaristata</i> - <i>Ceriops tagal</i>	1	-	-	3	5	<i>Avicennia marina</i>	3
41	Anson Bay, N.T.	13	130	<i>Avicennia marina</i> - <i>Ceriops tagal</i>	3	-	-	5-6	2-3	<i>Osbornia octodonta</i>	3
28	Darwin Harbour, N.T.	12	130	<i>Ceriops tagal</i> - <i>Campostemon schultzei</i>	1	-	-	2	4	<i>Xylocarpus australasicus</i>	2

(c) <i>Rhizophora stylosa</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
113	Gladstone, Qld	23	151	<i>Rhizophora stylosa</i>	2	4-5	95	1-2	5		
114	Keppel Bay, Qld	23	150	<i>Rhizophora stylosa</i>	1	5	95	2	5		
78	Bowen, Qld	20	148	<i>Rhizophora stylosa</i>	2	4.5-7.2	-	1-3	-	<i>Ceriops tagal</i>	-
82	Bowen, Qld	20	148	<i>Aegialitis annulata</i> - <i>Rhizophora stylosa</i>	2	2.6-6.6	-	2-3	-	<i>Aegialitis annulata</i>	-
89	Cape Ferguson, Qld	19	147	<i>Osbornia octodonta</i> - <i>Rhizophora stylosa</i>	3	5-7	40-80	3-6	3-4	<i>Osbornia octodonta</i>	1-2
93	Cairns, Qld	16	145	<i>Rhizophora stylosa</i> - <i>Rh. apiculata</i>	4	15-21	70-95	2-3	1-5	<i>Rhizophora apiculata</i>	+5
13	Russell Island, W.A.	15	128	<i>Rhizophora stylosa</i>	1	-	-	1	3	<i>Avicennia marina</i>	3
14	Fairfax & Russell Is., W	15	128	<i>Rhizophora stylosa</i>	2	-	-	2	4	<i>Campostemon schultzei</i>	3
124	Domette Point, WA	15	128	<i>Rhizophora stylosa</i>	1	4	-	2	-	<i>Avicennia marina</i>	-
133	Vansittart Bay, WA	14	124	<i>Rhizophora stylosa</i>	2	4.3-4.8	-	1-2	-	<i>Sonneratia alba</i>	-
11	Anson Bay, N.T.	13	130	<i>Rhizophora stylosa</i>	1	-	-	3	3	<i>Avicennia marina</i>	4
12	Anson Bay, N.T.	13	130	<i>Rhizophora stylosa</i>	1	-	-	2	4	<i>Campostemon schultzei</i>	2
8	Darwin Harbour, N.T.	12	130	<i>Rhizophora stylosa</i>	1	-	-	3	3	<i>Sonneratia alba</i>	2
9	Anson Bay, N.T.	12	130	<i>Rhizophora stylosa</i>	1	-	-	3	3	<i>Sonneratia alba</i>	2
10	Anson Bay, N.T.	12	130	<i>Rhizophora stylosa</i>	2	-	-	4	3	<i>Sonneratia alba</i>	2-3

(d) <i>Excoecaria agallocha</i> -dominated Vegetation											
ID	Location	Lat.	Long.	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
2	Ballina, NSW	28	153	<i>Avicennia marina</i> - <i>Excoecaria agallocha</i>	1	9	40	5	3.3	<i>Avicennia marina</i>	3.3
112	Keppel Bay, Qld	23	150	<i>Lumnitzera racemosa</i> - <i>Excoecaria agal.</i>	1	3	85	2	4	<i>Lumnitzera racemosa</i>	3
61	near Derby, W.A.	17	123	<i>Avicennia marina</i> - <i>Batis argillicola</i>	1	-	-	6	3	<i>Avicennia marina</i>	2-3
44	Broome township, W.A.	17	122	<i>Excoecaria agallocha</i>	1	-	-	2	4	<i>Ceriops tagal</i>	2
53	Willie Creek, W.A.	17	122	<i>Excoecaria agal.</i> - <i>Sporobolus virginicus</i>	2	-	-	4-5	2-3	<i>Xerochloa imberbis</i>	4
48	Willie Creek, W.A.	17	122	<i>Excoecaria agallocha</i>	1	-	-	3	3	<i>Ceriops tagal</i>	3
52	Still Bay, etc, W.A.	15	128	<i>Excoecaria agal.</i> - <i>Sporobolus virginicus</i>	2	-	-	3-5	2-5	<i>Halosarcia indica</i>	2-3
46	Darwin Harbour, N.T.	12	130	<i>Excoecaria agallocha</i>	3	-	-	3-4	2-3	<i>Lumnitzera racemosa</i>	3-4

(e) *Sonneratia alba*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
96	Cairns, Qld	16	145	<i>Avicennia marina</i> - <i>Sonneratia alba</i>	1	7	95	3	4	<i>Avicennia marina</i>	2
4	Russell Island, W.A.	15	128	<i>Sonneratia alba</i>	2	-	-	1	3	-	-
7	Fairfax & Russell Is., N.	15	128	<i>Sonneratia alba</i>	3	-	-	2	2-3	<i>Avicennia marina</i>	3
125	Demott Point, WA	13	128	<i>Sonneratia alba</i>	1	8.1	-	3	-	<i>Rhizophora stylosa</i>	-
128	Lacrosse Is., WA	15	128	<i>Avicennia marina</i> - <i>Sonneratia alba</i>	2	5.8-6.5	-	3-4	-	<i>Avicennia marina</i>	-
3	Alton Bay, N.T.	13	130	<i>Sonneratia alba</i>	1	-	-	1	4	-	-
6	Anson Bay, N.T.	13	130	<i>Sonneratia alba</i>	1	-	-	3	3	<i>Avicennia marina</i>	2
5	Darwin Harbour, N.T.	12	130	<i>Sonneratia alba</i>	1	-	-	1	4	-	-

(f) *Xylocarpus australasicus*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
33	Anson Bay, N.T.	13	130	<i>Bruguiera exaristata</i> - <i>Xylocarpus aust.</i>	1	-	-	6	3	<i>Bruguiera exaristata</i>	2
34	Anson Bay, N.T.	13	130	<i>Bruguiera exaristata</i> - <i>Xylocarpus aust.</i>	1	-	-	4	4	<i>Avicennia marina</i>	4
35	Anson Bay, N.T.	13	130	<i>Bruguiera exaristata</i> - <i>Xylocarpus aust.</i>	4	-	-	3	3-5	<i>Bruguiera exaristata</i>	2-3
30	Darwin Harbour, N.T.	12	130	<i>Bruguiera exaristata</i> - <i>Xylocarpus aust.</i>	1	-	-	3	3	<i>Lumnitzera racemosa</i>	3
31	Darwin Harbour, N.T.	12	130	<i>Bruguiera exaristata</i> - <i>Xylocarpus aust.</i>	1	-	-	4	3	<i>Acrostichum speciosum</i>	3

(g) *Lumnitzera racemosa*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
108	Gladstone, Qld	23	151	<i>Ceriops tagal</i> - <i>Lumnitzera racemosa</i>	2	2-4.5	70-95	2-3	3-4	<i>Ceriops tagal</i>	2-3
109	Yeppoon, Qld	23	150	<i>Ceriops tagal</i> - <i>Lumnitzera racemosa</i>	1	3	80	3	4	<i>Ceriops tagal</i>	2
110	Keppel Bay, Qld	23	150	<i>Ceriops tagal</i> - <i>Lumnitzera racemosa</i>	2	2.5-3	85-95	3	5	<i>Ceriops tagal</i>	1-5
91	Cape Ferguson, Qld	19	147	<i>Lumnitzera racemosa</i>	1	2	30	1	3	-	-

(h) *Bruguiera exaristata*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
39	King Bay, W.A.	29	116	<i>Bruguiera exaristata</i> - <i>Ceriops tagal</i>	1	-	-	2	4	<i>Ceriops tagal</i>	2
40	Barred Creek, W.A.	17	122	<i>Bruguiera exaristata</i> - <i>Ceriops tagal</i>	1	-	-	4	3	<i>Ceriops tagal</i>	3
32	Darwin Harbour, N.T.	12	130	<i>Bruguiera exaristata</i> - <i>Xylocarpus aust.</i>	1	-	-	5	3	<i>Xylocarpus australasicus</i>	2
36	Darwin Harbour, N.T.	12	130	<i>Bruguiera exaristata</i> - <i>Ceriops tagal</i>	1	-	-	3	3	<i>Ceriops tagal</i>	2

(i) *Campostemon schulzei*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
16	near Derby, W.A.	17	123	<i>Avi. marina</i> - <i>Campostemon schulzei</i>	1	-	-	2	4	<i>Avicennia marina</i>	2
18	near Derby, W.A.	17	123	<i>Avi. marina</i> - <i>Campostemon schulzei</i>	2	-	-	1	4	<i>Avicennia marina</i>	2
21	near Derby, W.A.	17	123	<i>Avi. marina</i> - <i>Campostemon schulzei</i>	2	-	-	2	3-4	<i>Avicennia marina</i>	2-3

(j) *Rhizophora lamarcki*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
79	Bowen, Qld	20	148	<i>Rhizophora lamarcki</i>	2	4.4-4.7	-	2-4	-	<i>Ceriops tagal</i>	-
81	Bowen, Qld	20	148	<i>Rhizophora stylosa</i> - <i>Rh. lamarcki</i>	2	5.2-5.3	-	2-3	-	<i>Rhizophora stylosa</i>	-

(k) *Aegiceras coniculatum*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
99	Newcastle, NSW	32	151	<i>Aegiceras coniculatum</i>	2	5-8	90-95	2	4-5	<i>Avicennia marina</i>	1-2
88	Iluka, NSW	29	153	<i>Aegiceras coniculatum</i>	1	1.5	70	4	4.4	<i>Sesuvium portulacastrum</i>	3.3

(l) *Aegialitis annulata*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
83	Bowen, Qld	20	148	<i>Aegialitis annulata</i>	2	0.6-0.8	-	2-4	-	<i>Rhizophora stylosa</i>	-
132	Sandy Island	14	127	<i>Aegialitis annulata</i>	3	0.7-0.8	-	1-2	-	<i>Rhizophora stylosa</i>	-

(m) *Bruguiera parviflora*-dominated Vegetation

ID	Location	Lat	Long	Community	#	H(m)	Cover(%)	Sp.#	CD1	2nd dominant species	CD2
92	Mossman, Qld	16	145	<i>Bruguiera gymnorrhiza</i> - <i>Br. parviflora</i>	1	22	90	3	4	<i>Bruguiera gymnorrhiza</i>	3
94	Cairns, Qld	16	145	<i>Rhizophora stylosa</i> - <i>Br. parviflora</i>	2	8	70-80	4-5	3-4	<i>Avicennia marina</i>	3

#: No. of relevés, H (m): Height of vegetation (m), Cover (%): Cover of vegetation (%), Sp. #: No. of component species

CD1: Cover degree of dominant species, CD2: Cover degree of 2nd dominant species

Data: 1-2, 73, 87-94, 95-114: Original, 3-65: Bridgewater 1985, 74-79, 81-85: Saenger 1983, 86: Davie 1987, 124-133: Saenger (unpublished)

Guinea, New Zealand, and South-East and East Asia. Most of the component species were common to both Australia and East Asia. However, the distribution areas and the biodiversity in Australia are richer than in the equivalent latitudes of East Asia. Detailed phytosociological studies of mangroves in Australia might be important and useful in the analysis and classification of mangrove vegetation in South-East and East Asia.

Acknowledgements

This review was prepared while the author was on study leave at the Centre for Coastal Management, Southern Cross University in Lismore, Australia. In addition, we owe debts of gratitude to Professor D. F.

Gartside (Dean, Faculty of Resource Science and Management, Southern Cross University) for assistance with the study.

References

- Barth, H. (1981): The Biogeography of Mangroves. In: Sen, D.N. and K.S. Rajpurohit (eds). Contributions to the Ecology of halophytes. Vol. 2, Tasks for Vegetation Science, pp. 66-131. The Hague: Dr W. Junk.
- Beadle, N.C.W. (1981): The Vegetation of Australia. 690 pp. Cambridge University Press.
- Braun-Blanquet (1964): Pflanzensoziologie, 3 Aufl. 865 pp. Springer, Wien.
- Bridgewater, P.B. (1985): Variation in the mangal along the west coastline of Australia. Proc. Ecol. Soc.

- Aust. 13: 243-256. Canberra.
- Chapman, V.J. (1975): Mangrove Biogeography. In: Walsh, G.E., S.C. Snedaker and H.J. Teas (eds), Proceedings of the International Symposium on Biology and Management of Mangroves, Vol. 1, pp. 3-22. Gainesville Univ. Florida.
- Chapman, V.J. (1977): Introduction. In *Ecosystems of the World. I. Wet Coastal Ecosystems*, pp. 1-29. Amsterdam: Elsevier.
- Churchill, D.M. (1973): The Ecological Significance of Tropical Mangroves in the Early Tertiary Floras of Southern Australia. *Geol. Soc. Aust. Publ.* 4: 79-86.
- Clough, B.F. (ed.) (1982): *Mangrove Ecosystems in Australia*. Australian National University Press. Canberra.
- Crisp, P., L. Daniel and P. Tortell. (1990): *Mangroves in New Zealand: Trees in the Tide*. 69 pp. CP Books.
- Davie, J.D.S. (1987): Mangrove Ecosystems in Australia. *Mangrove Ecosystems of Asia and the Pacific (Proceedings of the Research for Development Seminar, Townsville, Australia, 1985)*. Australian Institute of Marine Science, p. 3-23. Townsville.
- Ding Hou. (1958) (1972): *Rhizophoraceae*. *Flora of Malaysia* (Ser. 1), 5: 429-293, 6: 965-967.
- Duke, N.C. (1992): Mangrove Floristics and Biogeography. In: Robertson, A.I. and Alongi, D.M. (eds). *Tropical Mangrove Ecosystems. Coastal and Estuarine Studies 41*. American Geophysical Union, Washington, DC. pp. 63-100.
- Hutchings, P. and P. Saenger. (1987): *Ecology of Mangroves*. 388 pp. University of Queensland Press.
- Lear, R. and T. Turner. (1977): *Mangroves of Australia*. 84 pp. University of Queensland Press.
- Macnae, W. (1966): Mangroves in eastern and southern Australia. *Aust. J. Bot.* 14: 67-104.
- Macnae, W. (1968): A General Account of the Fauna and Flora of Mangrove Swamps and Forests in the Indo-West-Pacific Region. *Adv. Mar. Biol.* 6: 73-270.
- Miyawaki, A. and K. Suzuki, (1980): Process of Phytosociological Studies and Vegetation Mapping. *Bull. Inst. Env. Sci. Techn. Yokohama Natn. Univ.* 7: 492-506.
- Miyawaki, A., K. Suzuki, S. Suzuki, Y. Nakamura et al. (1982): *Phytosociological Studies of Mangrove Vegetation in Japan. I. Mangrove Vegetation in Iriomote Island*. *Bull. Inst. Env. Sci. Techn. Yokohama Natn. Univ.* 9: 77-89.
- Nakamura, Y. (1989): Salt-marsh and Mangroves. In: Miyawaki, A. (ed.). *Vegetation of Japan. Vol. 2, Kyushu*. pp. 311-317. Shibundo. Tokyo.
- Peng, L. (1987): The Mangrove Ecosystem in China. In: C.D. Field and A.J. Dartnall (eds) *Mangrove Ecosystems of Asia and the Pacific, Proc. of Research for Development Seminar, Townsville, Australia, 1985*, pp. 40-52. Australian Institute of Marine Science.
- Saenger, P., and J. Moverley. (1985): Vegetative phenology of mangroves along the Queensland coastline. *Proc. Ecol. Soc. Aust.* 13:257-65.
- Saenger, P., R.L. Specht, M.M. Specht and V.J. Chapman, (1977): Mangal and Coastal Salt-marsh Communities in Australia. In: *Ecosystems of the World. I. Wet Coastal Ecosystem* (ed. V.J. Chapman), pp. 293-345. Elsevier, Amsterdam.
- Saenger, P. (1983): *Mangrove of Adelaide and Duck Creek, Bowen*. (Unpubl. Research Report)
- Semeniuk, V., K.F. Kenneally and P.G. Wilson. 1978. *Mangroves of West Australia*. Western Australian Naturalists' Club, Perth. 80 pp.
- Specht, R.L. (1981): Biogeography of Halophytic Angiosperms (saltmarsh, mangrove and seagrass). In: Keast, A. (ed.). *Ecological Biogeography of Australia*. pp. 577-589. The Hague: Dr W. Junk.
- Suzuki, K. (1979): *Vegetation of the Ryukyu Islands*. *Bull. Inst. Env. Sci. Techn. Yokohama Natn. Univ.* 5 (1): 87-150.
- Suzuki, K. (1980): Mangrove Vegetation. In: Miyawaki, A. (ed.). *Vegetation of Japan. Vol. 1, Yakushima*. pp. 118-120. Shibundo. Tokyo.
- Suzuki, K. (1981): Salt-marsh and Mangroves. In: Miyawaki, A. (ed.). *Vegetation of Japan. Vol. 2, Kyushu*. pp. 27-33. Shibundo. Tokyo.
- Walsh, G.E. (1974): Mangroves: A Review. In: Reinhold, R.J. and W.H. Queen (eds). *Ecology of Halophytes*. pp. 51-174. N.Y. Academic Press.
- Wells, A.G. (1983): Distribution of mangrove species in Australia. In: H.J. Teas (ed.). *Tasks for vegetation science*, vol. 8, pp. 57-76. The Hague: Dr W. Junk.