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STUDIES ON AUSTRALIAN MANGROVE ALGAE

I. Victorian Communities: Composition and Geographic Distribution

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ABSTRACT: This study of the algal communities associated with the temperate mangrove ecosystems of Victoria, Australia, documents the occurrence of 23 species including 6 Chlorophyta, 1 Chrysophyta, 3 Phaeophyta, and 13 Rhodophyta. Pertinent morphosystematic and distribution data are presented for each species. Although the Victorian mangrove algal flora is far more diverse than previously thought, it is exceedingly depauperate and pedestrian when compared with the southern Australian marine algal flora as a whole. Most species found are widely distributed on a global basis. Frequency data indicate that *Caloglossa leprieurii* occurs most commonly but that most species found occur only rarely or sporadically.

INTRODUCTION

Numerous accounts of mangrove vegetation have appeared since 1950 (see references listed in Chapman 1976, Lugo & Snedaker 1974, and Macnae 1968) and include various Australian based studies (e.g. Ashton 1972, Bird 1971, 1972, Clarke & Hannon 1967, 1969, 1970, 1971, Hutchings & Recher 1974, Macnae 1966, Ministry for Conservation, Victoria 1975, Saenger *et al* 1977). These reports, however, contain comparatively little data on the mangrove algal communities present. Indeed, most studies of mangrove algae have been confined to the tropics (e.g. Almodovar & Pagan 1971, Biebl 1962, Boergesen 1911, Burkholder & Almodovar 1974, Feldmann & Lami 1936, Kuenzler 1974, Post 1936 *et seq*, Taylor 1959, Tseng 1942, 1943).

In temperate regions (i.e. poleward of 30° lat.), mangroves occur only in southern Australia (Table 1) and northern New Zealand in the southern hemisphere, and only in southern Japan and in Bermuda in the northern hemisphere, but again, few algal data are available. Thus Hosokawa *et al* (1977) omit mention of algae in their review of Japanese mangrove ecosystems, while Collins and Hervey (1917) and Taylor and Bernatowicz (1969) present only cursory observations on Bermuda's mangrove algae. Similarly, only limited information is available for New Zealand (Chapman 1977, p 14, Chapman & Ronaldson 1958) and for southern Australia (Butler *et al* 1977a, 1977b, Post 1963, 1964a, Saenger *et al* 1977, Womersley & Edmonds 1958). No detailed floristic surveys of southern Australian mangrove algae have been undertaken, and virtually no ecological data have been collected.

This account presents results of studies on the algal communities associated with mangrove ecosystems in Victoria, Australia, in terms of composition, frequency of species occurrence and geographic distribution, and includes comparisons of these communities with one another, with the marine algal flora of southern Australia in general, and with mangrove algal communities elsewhere.

STUDY SITES

In Victoria, mangrove ecosystems are dominated entirely by *Avicennia marina* (Forster) Vierhapper and occur in five distinct regions (Fig. 1; Table 1). The mangroves generally form more or less open canopy scrub communities in which trees rarely exceed 4 m in height (Pl. 7, 1). This contrasts with tropical Australian mangrove ecosystems which generally develop multispecies closed forests with trees up to 30 m tall (Saenger *et al* 1977). The distribution of *Avicennia* in Victoria and southern Australia (Table 1) is probably controlled by winter air temperatures (Chapman 1976); in Melbourne the mean daily minimum temperature for July is 4°C (Macnae 1966). The stands of *Avicennia* (Pl. 7, 2) along the southern shore of Corner Inlet (38°55′ S) are the most poleward occurrences of mangroves known (Bird 1972).

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TABLE 1
LOCATIONS OF THE COOL TEMPERATE AUSTRALIAN MANGROVE ECOSYSTEMS

State	*Locality*	*References*
SOUTH AUSTRALIA	1. Ceduna - Streaky Bay Region	2, 4
	2. Gulf of St. Vincent (from Price to Port Adelaide)	2, 3
	3. Spencer Gulf (from Tumby Bay to Wallaroo)	2, 3
VICTORIA	1. Andersons Inlet	1
	2. Barwon Heads	1, 4
	3. Corner Inlet (from Millers Landing to east of Port Welshpool)	1, 4
	4. Port Phillip Bay (Hovells Creek and the Kororoit Creek Estuary)	1, 4
	5. Westernport Bay (from Sandy Pt. to Rhyll, Phillip Island)	1, 3, 4
WESTERN AUSTRALIA	1. Bunbury	3, 4

References: 1. Ashton (1972); 2. Butler *et al.* (1977a); 3. Macnae (1966); 4. Saenger *et al.* (1977).

Westernport Bay affords the most sheltered Victorian mangrove environment and much of the shoreline is fringed intertidally with *Avicennia* stands averaging 40-200 m in width. The trees are mostly 2-3 m tall, extend landward to the high tide mark, and produce numerous pneumatophores which serve as the main substrate for macroscopic algae (Pl. 7, 3). The next most extensive mangrove stands occur in Corner Inlet where most trees are 1-2 m tall and form stands which rarely exceed 40 m in width. In Andersons Inlet a more or less continuous fringe up to 20 m wide occurs with most trees less than 2.5 m tall. Comparatively poor developments of *Avicennia* occur at Barwon Heads and in Port Phillip Bay. At Kororoit Creek (Port Phillip Bay), the mangrove stand includes only one 2.0 m tall tree and 6 smaller trees.

MATERIALS AND METHODS

Entire *Avicennia* pneumatophores were collected randomly from throughout the mangrove fringe at 16 different localities between March and September 1977. Eight of the 16 study sites were in Westernport Bay, four in Corner Inlet, two in Port Phillip Bay and one each in Andersons Inlet and at Barwon Heads. The pneumatophores were field preserved in 1:10::formalin:seawater and returned to the laboratory for subsequent analyses. Species composition and frequency values were determined for each locality, noting reproductive status and other morphological features of interest for each algal taxon present. Microscopic Cyanophyta and Bacillariophyta have been excluded from this study.

Frequency data are based on observations of 10-40 pneumatophores collected in a random manner from near the seaward margin of each locality; a given frequency value is the ratio of the number of pneumatophores on which a particular alga occurred to the total number of pneumatophores sampled for frequency analyses at that locality. The relative profusion of taxa has been determined by assigning species to one of the following five categories based on frequency (F) values: *Rare* ($F < .05$); *Sporadic* ($F = .05\text{-}.24$); *Occasional* ($F = .25\text{-}.49$); *Common* ($F = .50\text{-}.75$); *Abundant* ($F > .75$). In the text the word 'prevalent' is used to include both the common and abundant frequency classes. This terminology represents a modification of that suggested by Kershaw (1973, pp. 9-12).

Herbarium vouchers, permanent slides and/or liquid preserved specimens of all species from each locality are deposited in LTB (Index Herbariorum abbreviation; see Holmgren & Keuken 1977, p. 485).

OBSERVATIONS

COMMUNITY COMPOSITION AND SPECIES DISTRIBUTION

Twenty-three species of coenocytic or multicellular eucaryotic algae (discussed below alphabetically within each division) occurred in the mangrove stands studied, including six Chlorophyta, one Chrysophyta, three Phaeophyta, and thirteen Rhodophyta. At each given locality from 2—13 species were detected (Table 2), and, with the exceptions of Hovells Creek and Kororoit Creek, red algae predominated in the community composition. Green algae occurred at all localities and red algae were collected from 15 of the 16 sample areas, while brown algae were found only at three study sites, and the Chrysophycean alga *Vaucheria* was encountered only once.

In the following list, data provided for each taxon include selected references of taxonomic or geographic significance, type locality, recorded geographic distribution, and brief notes relating to occurrence in Victorian mangrove ecosystems as well as data of taxonomic and/or morphologic interest.

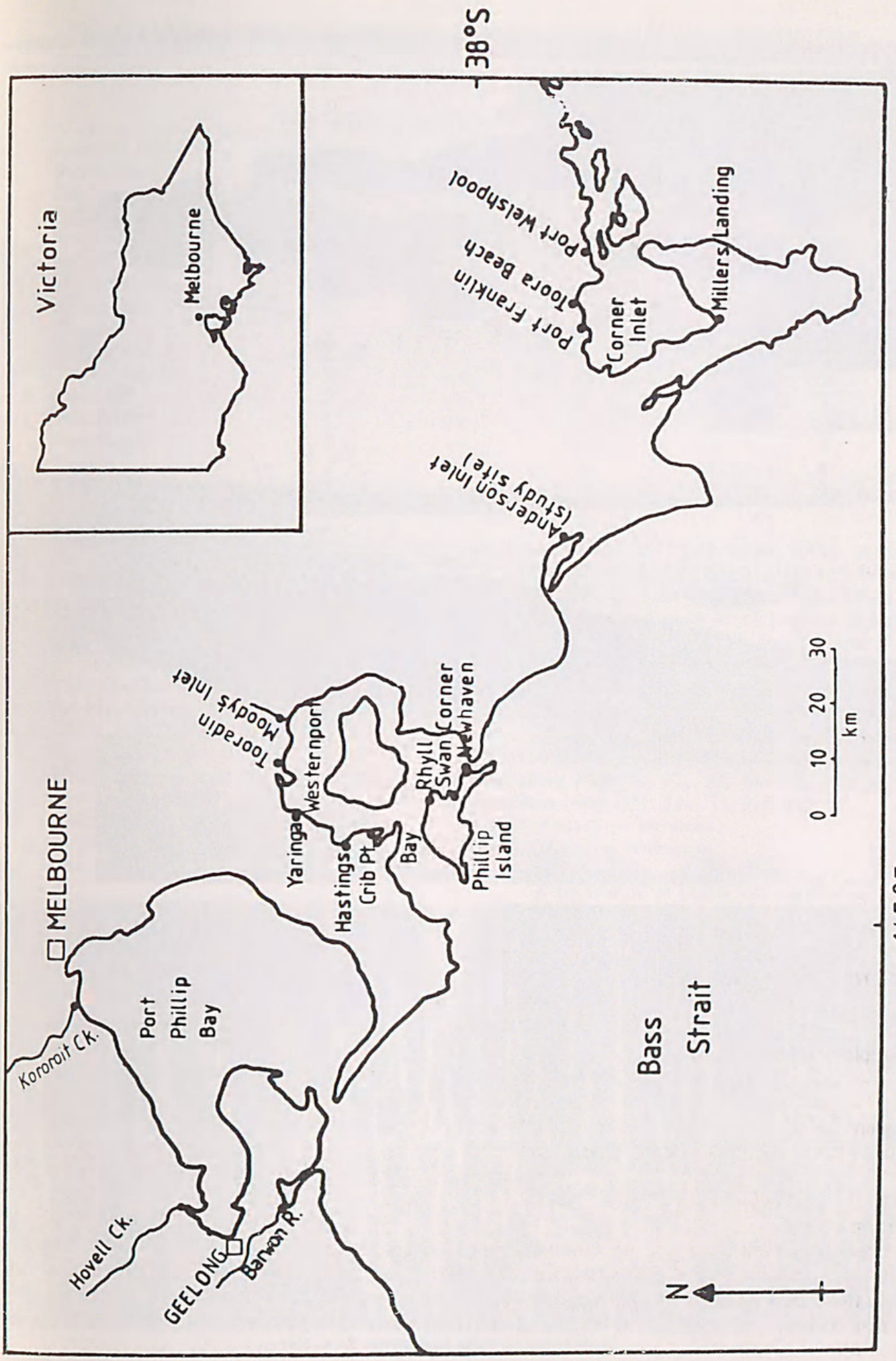

Fig. 1.—The 16 Victorian localities in which sampling was undertaken.

PLATE 7

TABLE 2
SUMMARY OF ALGAL COMMUNITY COMPOSITION DATA FOR VICTORIAN MANGROVE ECOSYSTEMS

Locality	*No. of Taxa from Each Division*				*Total*
	Chlorophyta	Chrysophyta	Phaeophyta	Rhodophyta	
Andersons Inlet	3	—	—	5	8
Barwon Heads	1	—	—	3	4
Crib Point	4	1	1	7	13
Hastings	3	—	—	5	8
Hovells Creek	2	—	—	1	3
Kororoit Creek	2	—	—	—	2
Millers Landing	2	—	—	4	6
Moodys Inlet	1	—	—	4	5
Newhaven	1	—	—	6	7
Port Franklin	2	—	—	4	6
Port Welshpool	2	—	2	5	9
Rhyll	2	—	—	6	8
Swan Corner	1	—	—	5	6
Toora Beach	3	—	—	5	8
Tooradin	2	—	—	6	8
Yaringa	2	—	2	9	13

Division CHLOROPHYTA

Genus **Chaetomorpha** Kuetzing, 1845

C. capillaris (Kuetzing) Boergesen 1925:45, Fig. 13. Womersley 1956:356.

TYPE LOCALITY — Nice, south of France.

DISTRIBUTION — Mediterranean and nearby Atlantic Ocean. In Australia, from American River Inlet, Kangaroo Island, and Westernport Bay, Victoria.

SPECIMENS EXAMINED — LTB 10336, 10347, 10358, 10374, 10380, 10387, 10393.

C. capillaris occurred at all Westernport localities studied except for Moodys Inlet and usually was encountered sparingly in association with *Bostrychia* and *Caloglossa*.

Genus **Cladophora** Kuetzing, 1843

Cladophora sp.

SPECIMENS EXAMINED — LTB 10326, 10350, 10359.

Young plants up to 4 mm tall were found attached to *Avicennia* pneumatophores at Hastings, Millers Landing, and Yaringa. Cells ranged in size from 30-40 μm broad and from 130-170 μm long, but reliable species identification of these diminutive plants was not possible.

Genus **Enteromorpha** Link, 1820

E. clathrata (Roth) Greville 1830: 181. Bliding 1963: 107, Fig. 64-68. Kylin 1949: 28, Fig. 27-29. Womersley 1950: 142; 1956: 352.

TYPE LOCALITY — Europe (see Womersley 1956, p. 352).

DISTRIBUTION — Widespread.

SPECIMENS EXAMINED — LTB 10187, 10193, 10203, 10211, 10219, 10224, 10318, 10327, 10337, 10351, 10374, 10394.

E. clathrata was encountered more often than any other green alga and grew at all stations except Hovells Creek, Newhaven, Swan Corner and Yaringa. It predominated the algal flora of pneumatophores at Kororoit Creek, but occurred only as scattered plants elsewhere.

Genus **Percursaria** Bory, 1828

P. percursa (C. Agardh) Rosenvinge 1893: 963. Abbott and Hollenberg 1976: 70, Fig. 23. Bliding 1963: 20, Fig. 5-6. Papenfuss 1960: 311, 314. Taylor 1960: 54.

TYPE LOCALITY — Denmark.

DISTRIBUTION — Widespread.

SPECIMEN EXAMINED — LTB 10205.

A population of plants was encountered at Hovells Creek but at none of the other study sites. This species apparently has not been recorded previously from southern Australia (see Womersley 1956, 1971).

Genus **Rhizoclonium** Kuetzing, 1843

R. riparium (Roth) Harvey 1851: pl. 239. Cribb 1954: 17, pl. 1, Fig. 9. Taylor 1957: 81, pl. 1, Fig. 3. Womersley 1956: 361.

TYPE LOCALITY — Northern Europe

DISTRIBUTION — Cosmopolitan

SPECIMENS EXAMINED — LTB 10206, 10220, 10319, 10338.

R. riparium plants occurred on *Avicennia* at Andersons Inlet and infrequently among *Caloglossa* and/or *Percur-*

EXPLANATION OF PLATE 7

1. The mangrove community at Rhyll showing the open canopy common in Victorian mangrove ecosystems. 2. The most poleward known mangrove community at Millers Landing, Corner Inlet, Victoria. Trees average 2 m in height. 3. *Avicennia* pneumatophores near the seaward fringe at low tide with associated algal communities

saria at Hovells Creek. Single specimens also were recorded from Crib Point and Toora Beach pneumatophores.

Genus **Ulva** Linnaeus, 1753

U. lactuca Linnaeus 1753: 1163. Bliding 1968: 540, Figs. 3-5. Womersley 1956: 353.
TYPE LOCALITY — Sweden.
DISTRIBUTION — Widespread.
SPECIMENS EXAMINED — LTB 10188, 10194, 10212, 10218, 10320, 10339.

Plants of *U. lactuca* occurred profusely on pneumatophores at Kororoit Creek and also grew conspicuously at stations along the North shore of Corner Inlet and in Andersons Inlet. One plant was found in Westernport Bay (Crib Point).

Division CHRYSOPHYTA

Genus **Vaucheria** deCandolle, 1801

Vaucheria sp.
SPECIMEN EXAMINED — LTB 10340.

Plants with several immature oogonia and antheridia and siphons up to 50 μm broad were entangled with *Chaetomorpha capillaris* on pneumatophores at Crib Point. Reliable species determination was not possible.

Division PHAEOPHYTA

Genus **Ectocarpus** Lyngbye, 1819

E. siliculosus (Dillwyn) Lyngbye 1819:131. Russell 1966:275, Figs. 3-4. Womersley 1967:190.
TYPE LOCALITY — Europe.
DISTRIBUTION — Widespread in temperate and boreal seas.
SPECIMENS EXAMINED — LTB 10341, 10360.

Plants up to 4 mm tall bearing plurilocular sporangia were encountered at the base of pneumatophores at Crib Point and Yaringa.

Ectocarpus sp.
SPECIMEN EXAMINED — LTB 10195.

Large sterile tufts of this taxon colonized a pneumatophore at Port Welshpool. Branching was mostly alternate and the main axes were ecorticate. Cells contained several more or less ribbon like chromoplasts and were up to 25μm broad and 40 μm long in the main axes. The absence of sporangia precluded accurate species identification.

Genus **Sphacelaria** Lyngbye, 1819

S. fusca (Hudson) C. Agardh 1828:34. Sauvageau 1902:206, Fig. 43. Taylor 1960:210. Womersley 1967: 199.
TYPE LOCALITY — Britain.
DISTRIBUTION — Reported from Bermuda, England, Northern France and southern Australia.
SPECIMENS EXAMINED — LTB 10198, 10361.

Several plants were found on pneumatophores at Port Welshpool and Yaringa. The specimens were mostly 3-4 mm tall and bore triradiate non-constricted, linear-armed propagula without central hairs.

Division RHODOPHYTA

Genus **Audouinella** Bory, 1823

A. microscopia (Naegeli) Woelkerling 1971:33, Figs. 10, 23A. Woelkerling 1972:85 *et seq*, Figs. 1-14, 1973a:86; 1973b:557, Figs. 46-51.
TYPE LOCALITY — Bay of Naples, Italy.
DISTRIBUTION — Widespread
SPECIMEN EXAMINED — LTB 10362.

One immature 6-celled plant grew epiphytically on a *Cladophora* plant attached to a pneumatophore at Yaringa.

Genus **Bostrychia** Montagne, 1842

B. intricata (Bory) Montagne 1852:317, Kuetzing 1865:9, pl. 23, figs, d-f. Tseng 1943:174, pl. 1, figs. 4-5.
TYPE LOCALITY — Falkland Islands.
DISTRIBUTION —Widespread in subantarctic regions and in warmer waters on littoral zone rocks, muds and mangroves.
SPECIMENS EXAMINED — LTB 10215, 10221B, 10357, 10371, 10379, 10386, 10392.

Plants of *B. intricata* were commonplace on *Avicennia* pneumatophores at Toora Beach and also all Westernport Bay localities except Crib Point and Hastings. All specimens examined were sterile and grew intermixed with other species of *Bostrychia*. Use of the name *B. intricata* rather than *B. mixta* Hooker and Harvey follows Tseng (1943), who regards the latter as a synonym of *B. intricata*. Post (1963, 1964a) records this taxon (as *B. mixta*) from littoral zone mud surfaces on Kangaroo Island, S.A., and at Tidal River, Victoria. Both localities are devoid of mangroves. Saenger *et al* (1977 p. 317) also record this taxon (as *B. mixta*) from mud and *Avicennia* pneumatophores in Queensland.

B. moritziana (Sonder in Kuetzing) J. Agardh 1863:862. Post 1936:10; 1963:57; 1964a:244. Taylor 1960:596.
TYPE LOCALITY — French Guiana.
DISTRIBUTION — Widespread in tropical and temperate seas.
SPECIMENS EXAMINED — LTB 10191, 10201, 10207, 10213, 10221A, 10321, 10328, 10334, 10348, 10355, 10369, 10377, 10384, 10390.

B. moritziana was encountered at more localities than any other species of *Bostrychia* and occurred everywhere except at the two Port Phillip Bay study sites. Plants often clothed *Avicennia* pneumatophores and in some cases bore cystocarps or tetrasporangia. Male plants were not observed. Specimens from southern Australia examined by Post (1963, 1964a) grew on littoral zone mud flats and rocks as well as on *Avicennia*.

B. radicans (Montagne) Montagne 1850:286. Post 1936:13; 1963:53; Taylor 1960:595. Tseng 1943:168, pl. 1, Figs. 1-3.
TYPE LOCALITY — Sinnamary, French Guiana.
DISTRIBUTION — Widely distributed in tropical and temperate waters.
SPECIMENS EXAMINED — LTB 10192, 10202, 10208, 10214, 10322, 10329, 10335, 10349, 10356, 10370, 10378, 10385, 10391.

The Victorian distribution of *B. radicans* and *B. moritziana* appear to be identical except for the absence of *B. radicans* at Moodys Inlet, and the two taxa almost always grew intermixed on pneumatophores. *B. radicans* plants also occurred epiphytically on *Caloglossa* and *Catenella*. Tetrasporic and cystocarpic plants of *B. radicans* were encountered on occasion, but male plants were not observed. Apparently, this taxon has not been reported from southern Australia before, but Saenger *et al* (1977) record it from Queensland.

B. scorpioides (Gmelin) Montagne 1842:39. De Toni 1905:1164. Falkenberg 1901:519, pl. 12, figs. 1-2. Kuetzing

1865:7, pl. 18, figs. a-d. Post 1936:34; 1963:78; 1964a:242. Taylor 1960:597.

B. harveyi Montagne 1852:317. De Berg 1949:499. De Toni 1905:1163. Garnet 1971:95. Harvey 1860:299; 1863:pl. 292.

TYPE LOCALITY — Great Britain.

DISTRIBUTION — Widely distributed in tropical and temperate waters.

SPECIMEN EXAMINED—LTB 10323.

Sterile plants of *B. scorpioides* grew on *Avicennia* pneumatophores at Andersons Inlet, but were not found elsewhere. Post (1964a) also recorded this species on mud from Tidal River, Leonard Bay and Sealers Cove at Wilsons Promontory. Application of the names *B. scorpioides* and *B. harveyi* to Australian plants requires further clarification including examination of relevant type collections. Post (1936, p. 34) considered *B. harveyi* to be a later synonym of *B. scorpioides*; however, de Berg (1949) argued that the two taxa are distinct, based on studies of New Zealand plants. Nevertheless Post (1963, 1964a) subsequently maintained that *B. harveyi* is identical to *B. scorpioides*, and until the matter can be clarified further from studies of additional Australian collections and comparisons with the types, it seems logical to follow Post, who has examined both Australian and European material. Saenger *et al* (1977, p. 317) also use the name *B. scorpioides*.

Genus **Caloglossa** J. Agardh, 1876

C. leprieurii (Montagne) J. Agardh 1876: 499. Dawson 1956: 57, Fig. 59. Feldmann & Lami 1936: 883. Papenfuss 1961: 8, Figs. 1-4. Post 1936: 46; 1963: 99; 1964a: 242. Womersley & Bailey 1970: 327.

TYPE LOCALITY — Cayenne, French Guiana.

DISTRIBUTION — Widespread in tropical and temperate waters.

SPECIMENS EXAMINED — LTB 10190, 10200, 10204, 10209, 10216, 10222, 10324, 10330, 10333, 10346, 10354, 10368, 10376, 10383, 10389.

C. leprieurii occurred at all localities except Kororoit Creek, thus making it the most widely distributed alga in Victorian mangrove ecosystems. In some cases it was the sole alga present on a given pneumatophore. Tetrasporangial and cystocarpic plants were observed on occasion, but most plants were sterile. King *et al* (1971), Post (1963, 1964a), Saenger *et al* (1977), and Sonder (1855, as *Delesseria*) previously recorded *C. leprieurii* from Victoria.

Genus **Catenella** Greville, 1830

C. nipae Zanardini 1872: 143, pl. 6A, Figs. 1-7. Min-Thein & Womersley 1976: 50, Figs. 17, 56. Post 1936: 68; 1963: 116, Fig. 8; 1964a: 251. Tseng 1942: 143.

TYPE LOCALITY — Sarawak, Borneo.

DISTRIBUTION — India, Indonesia, eastern and southeastern Australia, New Zealand (see Post 1936, 1963).

SPECIMENS EXAMINED — LTB 10189, 10210, 10217, 10223, 10325, 10331, 10332, 10345, 10353, 10367, 10375, 10382, 10388.

C. nipae occurred conspicuously on pneumatophores at all localities in Westernport Bay, Andersons Inlet, and Corner Inlet, but was not found in Port Phillip Bay or at Barwon Heads. Tetrasporic plants were commonplace and cystocarpic plants infrequent. Often *C. nipae* occurred as the sole alga on a particular pneumatophore.

Genus **Centroceras** Kuetzing, 1841

Centroceras sp.

SPECIMEN EXAMINED — LTB 10342.

A solitary sterile plant 6 mm tall occurred at the base of a pneumatophore at Crib Point. The filaments were up to 100 μm broad and successive nodes were separated by 11-12 cells, but reliable species identification was not possible.

Genus **Ceramium** Roth 1797

Ceramium macilentum J. Agardh 1894: 15. Womersley 1978: 232.

TYPE LOCALITY — Port Phillip Bay, Victoria.

TYPE — LD.

DISTRIBUTION — see Womersley 1978.

SPECIMEN EXAMINED — LTB 10343.

A single sterile tuft of filaments was encountered on one Crib Point pneumatophore.

Genus **Chondria** C. Agardh, 1817

Chondria sp.

SPECIMEN EXAMINED — LTB 10352.

Several tetrasporangial plants 4-5 cm tall colonized the lower half of a pneumatophore at Hastings. The tetrasporangial branches were markedly flattened and the sporangia averaged 40 μm in diameter.

Genus **Colaconema** Batters, 1896

C. humilis (Rosenvinge) Woelkerling 1971: 44, Figs. 15 J-O; 1937b: 529, Figs. 66-73.

TYPE LOCALITY — Spodobjerg, Langeland, Denmark.

DISTRIBUTION — Atlantic and Mediterranean shores of Europe, northeastern United States, southeastern Australia.

SPECIMEN EXAMINED — LTB 10363.

Plants occurred on an unidentified red alga epiphytic on a pneumatophore at Yaringa.

Genus **Diplocladia** Kylin, 1956

D. patersonis (Sonder) Kylin 1956: 504.

TYPE LOCALITY — Cape Paterson, Victoria.

DISTRIBUTION — S. Australia, Tasmania, Victoria.

SPECIMENS EXAMINED — LTB 10196, 10364.

Sterile plants up to 1.5 cm tall, colonized pneumatophores at Yaringa and Port Welshpool.

Genus **Polysiphonia** Greville, 1824

Polysiphonia sp.

SPECIMENS EXAMINED — LTB 10344, 10365, 10374, 10381, 10395.

Single tetrasporangial plants grew on pneumatophores at Crib Point, Newhaven, Rhyll, Tooradin and Yaringa. In all cases the plants were ecorticate with four pericentral cells, but reliable specific identification could not be made.

FREQUENCY DATA

Based on frequency data (Table 3), seven taxa (*Audouinella microscopica*, *Centroceras* sp., *Ceramium macilentum*, *Chondria* sp., *Colaconema humilis*, *Sphacelaria fusca*, *Vaucheria* sp.) of the total

TABLE 3
FREQUENCY OF SPECIES OCCURRENCE FROM THE 16 LOCALITIES STUDIED IN VICTORIA

Locality	Andersons Inlet	Barwon Heads	Crib Pt.	Hastings	Hovells Creek	Kororoit Creek	Millers Landing	Moodys Inlet	Newhaven
No. of pneumatophores sampled	40	39	25	26	39	16	30	10	22
Taxon									
CHLOROPHYTA									
Chaetomorpha capillaris			.32	.23					.23
Cladophora sp.				.03			.07		
Entermorpha clathrata	.03	.26	.04	.03		1.0	.07	.50	
Percursaria percursa					.23				
Rhizoclonium riparium	.55		.04		.23				
Ulva lactuca	.05		.04			1.0			
CHRYSOPHYTA									
Vaucheria sp.			.04						
PHAEOPHYTA									
Ectocarpus siliculosus			.04						
Ectocarpus sp.									
Sphacelaria fusca									
RHODOPHYTA									
Audouinella microscopica									
Bostrychia intricata								.90	.27
B. moritziana	.05	.26	.68	.73			.80	.40	.50
B. radicans	.40	.46	.60	.73			.54		.77
B. scorpioides	.25								
Caloglossa leprieurii	.43	1.0	.96	.96	1.0		.80	.30	.55
Catenella nipae	.68		.64	.53			.30	.30	.64
Centroceras sp.			.04						
Ceramium sp.			.04						
Chondria sp.				.03					
Colaconema humilis									
Diplocladia patersonis									
Polysiphonia sp.			.04						.05

TABLE 3 (*Continued*)

Locality	Port Franklin	Port Welshpool	Rhyll	Swan Corner	Toora Beach	Tooradin	Yaringa	
No. of pneumatophores sampled								
Taxon	24	40	21	23	40	24	25	$\bar{F}$
CHLOROPHYTA								
Chaetomorpha capillaris			.19	.17		.29	.36	.26
Cladophora sp.							.04	.05
Enteromorpha clathrata	.29	.38	.09		.18	.04		.24
Percursaria percursa								.23
Rhizoclonium riparium					.03			.21
Ulva lactuca	.08	.10			.10			.23
CHRYSOPHYTA								
Vaucheria sp.								.04
PHAEOPHYTA								
Ectocarpus siliculosus							.08	.06
Ectocarpus sp.		.05						.05
Sphacelaria fusca		.03					.04	.04
RHODOPHYTA								
Audouinella microscopica							.04	.04
Bostrychia intricata			.19	.69	.15	.17	.08	.35
B. moritziana	.38	.40	.72	.50	.50	.75	.68	.53
B. radicans	.29	.33	.67	.53	.53	.75	.68	.56
B. scorpioides								.25
Caloglossa leprieurii	.54	.75	.48	.60	.60	.83	.56	.69
Catenella nipae	.67	.48	.38	.53	.53	.79	.64	.55
Centroceras sp.								.04
Ceramium macilentum								.04
Chondria sp.								.03
Colaconema humilis							.04	.04
Diplocladia patersonis		.08					.04	.06
Polysiphonia sp.			.05			.04	.04	.04

of 23 recorded must be considered rare (F < .05 for all localities) and an additional six (*Cladophora* sp., *Diplocladia patersonis*, *Ectocarpus siliculosus*, *Ectocarpus* sp., *Percursaria percursa*, *Polysiphonia* sp.) classed as rare (F < .05) or sporadic (F = .05-.24) depending on the locality. This includes two of the six species of Chlorophyta, all of the Chrysophyta and Phaeophyta and seven of the 13 Rhodophyta. All of these species appear to be relatively inconsequential in Victorian mangrove ecosystems.

Of the remaining 10 taxa, four (*Bostrychia moritziana*, *B. radicans*, *Caloglossa leprieurii*, and *Catenella nipae*) were common (F = .50-.75) or abundant (F > .75) at most localities of occurrence, and six (*Bostrychia intricata*, *B. scorpioides*, *Chaetomorpha capillaris*, *Enteromorpha clathrata*, *Rhizoclonium riparium*, *Ulva lactuca*) showed marked variations in frequency values and could be considered rare to abundant depending upon locality. Based on mean frequency values [i.e. $\sum F/N$, where $\sum$'F' is the sum of all recorded frequencies -> 0 and 'N' is the total number of localities at which the alga occurred; (see Table 3)], *Caloglossa leprieurii* is the most conspicuous alga in the Victorian mangrove ecosystems.

At any given locality (Table 3) from 1-5 species of algae were common (F = .50-.75) or abundant (F > .75). In two instances (Andersons Inlet, Moodys Inlet) one of the prevalent species (F = .50-1.0) was a green alga, and in one other instance (Kororoit Creek), both prevalent species were green algae. For the remaining 13 localities, common or abundant frequency values occurred only among red algae.

At half the study sites, only one or two species had frequency values of .50 or greater; at the other study sites, from three to five species occurred with frequency values of .50 or more. No clear relationship, however, seems to exist between the number of prevalent species and the total number of species present at a locality (Table 4).

TABLE 4
RELATIONSHIPS BETWEEN THE NUMBER OF PREVALENT ALGAL SPECIES (F = .50 — 1.0) AND THE TOTAL NUMBER OF ALGAL SPECIES IN VICTORIAN MANGROVE ECOSYSTEMS

Locality	*# Prevalent Species*	P_s/T_s[1]
Barwon Heads	1	.25
Hovells Creek	1	.33
Port Welshpool	1	.11
Andersons Inlet	2	.25
Kororoit Creek	2	1.00
Moodys Inlet	2	.40
Port Franklin	2	.33
Rhyll	2	.25
Millers Landing	3	.50
Crib Point	4	.31
Hastings	4	.50
Newhaven	4	.57
Toora Beach	4	.50
Tooradin	4	.50
Yaringa	4	.31
Swan Corner	5	.83

[1] P_s = Number of prevalent species; T_s = Total number of species.

DISCUSSION

The algal flora of Victoria's mangrove ecosystems is exceedingly depauperate and pedestrian when compared with the southern Australian marine algal flora as a whole. Based on published species estimates (Womersley 1959), only six of the 98 Chlorophyta, three of the 191 Phaeophyta, and thirteen of the 725 Rhodophyta species known to occur in southern Australian seas were encountered in Victorian mangrove ecosystems. (Data on the Chrysophyta are too meagre to make meaningful comparisons). This represents percentage occurrences of 6.1, 1.6, and 1.8 respectively. Furthermore, only two (*Ceramium macilentum*; *Diplocladia patersonis*) of the 23 taxa found are endemic to southern Australia; the remaining taxa all have been recorded outside Australian waters, and most are widespread. Two species (*Bostrychia radicans*, *Percursaria percursa*), however, apparently have not been reported from southern Australia previously. All 23 species are known to occur outside of mangrove environments, but six species encountered in this study (*Audouinella microscopica*, *Colaconema humilis*, *Diplocladia patersonis*, *Ectocarpus siliculosus*, *Percursaria percursa*, *Sphacelaria fusca*) apparently have not been reported previously from mangrove ecosystems.

Of the 16 localities examined, four (Barwon Heads, Hovells Creek, Kororoit Creek, Moodys Inlet) were estuarine in nature, while 12 were not subject to the influence of fresh or brackish water. The total flora at these four localities was less diverse (2-5 taxa) than that of the more marine sites (6-13 taxa), and only one species (*Percursaria percursa*) appeared to be confined to these estuarine environments. In contrast, 14 species occurred only in the marine environments (Table 3). The four ecologically most significant algae (based on frequency values, see Table 3) all occurred at every marine locality sampled; however, none occurred at Kororoit Creek. In addition, *Bostrychia radicans* did not occur at Moodys Inlet, and *Catenella nipae* was not found at Barwon Heads. Thus, estuarine influence appears to affect adversely algal diversity within the mangrove ecosystems investigated.

Results from this study also suggest that the Victorian mangrove algal flora (i.e. Chlorophyta,

TABLE 5
COMPARISONS OF ALGAL FLORAS RECORDED FROM VARIOUS AUSTRALIAN MANGROVE ECOSYSTEMS BASED ON DATA FROM SAENGER *et al.* 1977 AND THIS STUDY

Taxon	*Victoria (Present Study)*	*Victoria (Saenger et al.)*	*N.S.W.*	*Qld.*	*Australia (Saenger et al. and This Study)*
Chlorophyta	6	—	—	5	7
Chrysophyta	1	—	—	—	1
Phaeophyta	3	—	—	1	4
Rhodophyta	13	3	4	17	24
Total	23	3	4	23	36
Bostrychia	4	2	3	7	7
Caloglossa	1	1	—	3	3
Catenella	1	—	1	1	1
Total	6	3	4	11	11

Phaeophyta, Rhodophyta) is far more diverse than previously realized and that its species richness may be comparable to that of Queensland mangrove ecosystems (Table 5). Thus 20 (87%) of the 23 species found during this study were not recorded previously from Victorian mangroves, and the species total for Victoria is now identical with that reported (Saenger *et al* 1977) for tropical Queensland. Species composition in the two areas differs substantially, however, and none of the Chrysophyta or Phaeophyta are common to both regions. Four of the seven Chlorophyta and six of the 24 Rhodophyta occur in both regions, and in the total floras, less than one-third (28%) of the algal species are reported from both tropical Queensland and temperate Victorian mangrove environments. Comparisons of species distribution of *Bostrychia*, *Caloglossa* and *Catenella* indicate that all species of these genera found on Victorian mangroves are also recorded from Queensland mangroves, and reveal also that 2 additional species of *Caloglossa* and 3 of *Bostrychia* occur (based on published records) only on Queensland mangroves. Such comparisons must be viewed with caution, however, since the Queensland data are based solely upon investigations of *Avicennia* pneumatophores, and studies of the algal flora associated with other Queensland mangrove species may produce data which will markedly alter statements made here. The absence of data precludes comparisons of the Victorian and Queensland mangrove algal floras with those of the Northern Territory, South Australia and Western Australia. Likewise data from New South Wales are too meagre (Table 5) to permit meaningful comparative discussions.

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