PROCEEDINGS
OF THE
ROYAL SOCIETY OF VICTORIA

NEW SERIES
VOLUME 82

ROYAL SOCIETY'S HALL
9 VICTORIA STREET, MELBOURNE 3000

1969

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East Gippsland Symposium

29 January 1969

THE REGION OF EAST GIPPSLAND

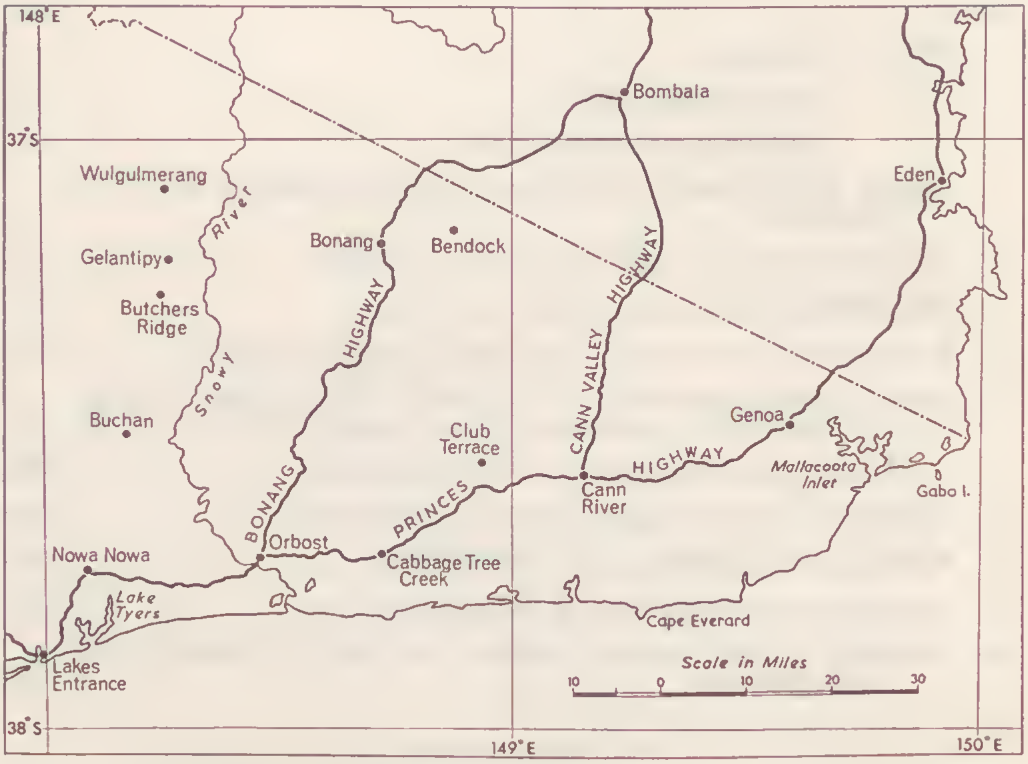

FIG. 1—The region of East Gippsland, as defined for purposes of the Symposium, extends E. from the 148th parallel, and from the Victorian border (diagonal broken line) to the sea. (Sketch map prepared by Mr H. J. Collier of the Geography Department, University of Melbourne.)

EAST GIPPSLAND SYMPOSIUM
14 SEPTEMBER, 1967

FOREWORD

A one-day symposium on East Gippsland was held on 14 September 1967. The region is defined for the purpose of the symposium as lying east of the 148th parallel and between the main Divide and the sea; the accompanying Figure shows the area and major towns. It is a distinctive region in its climate and ecology, having more generous summer rain than other parts of the State; it is also little known and little developed by man as compared with other parts. The object of the symposium was to bring together the many kinds of scientific information available on this region and to stimulate further research through discussion. The symposium was organized along the lines of three previous symposia, namely those on the High Plains of Victoria, on the basalt plains of Western Victoria, and on the Victorian Mallee, published respectively in volumes 75, 77, and 79 of the Proceedings.

The Council of the Society has decided to publish this Symposium as a separate Part since it will have its own interest and attraction beyond the membership of the Society.

G.W.L.

ALFRED WILLIAM HOWITT

By courtesy of the Victorian Department of Mines, sketches of Gippsland by Alfred William Howitt are used in this number of the Proceedings. These particular drawings were used to illustrate his classic paper, 'Notes on the Devonian Rocks of North Gippsland' (1876). Though slight, they are quite charming, and an apposite supplement to the Symposium on East Gippsland. Howitt is of particular interest to the Royal Society of Victoria not only because of his contributions to the geology, botany and anthropology of the particular area covered by this Symposium, but also because of his long personal association with the Society itself.

He was born in Nottingham, England, 1830 and died at Metung, Victoria, 1908. Both his parents were distinguished writers who numbered amongst their friends Charles Dickens, the Brownings, Hans Christian Andersen, Tennyson, the Rosettis. Howitt's literary heritage is apparent in the vivid wording of his own extensive writing. With his father and a brother, he migrated to Victoria in the gold-rush of 1852. Their search for gold was unsuccessful, but Howitt stayed on in Australia after his relatives left in 1854, and in the next few years had various occupations. He was a very intelligent man, educated in Germany as well as in England, and the space of Australia, so little explored, challenged him. He became an extremely skilled bushman. 'I am naturally a savage and must have open air and forests which are necessary to my existence', he wrote in a letter home, ex-

Mt. Tambo from the Omeo station. (*A. W. Howitt, 1876.*)

plaining why he did not wish to return. 'I have a great hankering after tent life.'

Subsequently, he was a member of an expedition led by Blandowski of the Melbourne Museum to explore the Mornington Peninsula. He worked on a cattle station at Cape Schanck, on a small farm at Caulfield, managed a sheep station at Thalia Plains, and from there explored north into South Australia to assess the nature of the country for pastoral use. Partly because of this experience of the terrain, but also because of his outstanding qualities as leader, explorer and bushman, he was chosen, 1861, by the Royal Society of Victoria to lead the Burke and Wills Relief Expedition to the Centre. His own account of this journey was vividly presented, many years later, in his Presidential Address to the Australian Association for the Advancement of Science, Adelaide, 1907.

> From Burke's 60th. camp we followed the course of Cooper's Creek, passing his first depot and then coming to his second depot, Fort Wills. . . The country we crossed consisted in great part of earthy plains, cracked and fissured in all directions, and often without any trace of vegetation; while in other places the dried stalks of plants, higher than a horse, showed what the country would be like after floods . . .
>
> I turned towards the river, and came to it near the lower end of a very large sheet of water, and where I saw, on the opposite side of the dry channel, a number of native huts. . . (My) blackboys . . . rode toward me. As we met the elder one said, "Find em whitefella; two fella dead boy and one fella livo." Hastening on and crossing over to the native camp, I found John King sitting in one of the native wurleys. He was a melancholy object, and hardly to be distinguished as a civilized being by the remnants of the clothes on him. He was not only very weak, but much overcome by our arrival, and it was at first difficult to make out what he said. . .
>
> It was Mr. Welch who, riding in the lead, first saw a strange figure sitting on the bank and said, "Who are you?" To which the reply was, "John King, the last survivor of Burke's party. Thank God, I am saved!"

In 1863 Howitt was appointed Warden of the Goldfields and Police Magistrate for North and East Gippsland, and he lived in this district subsequently for more than 30 years, until 1899. He travelled continuously, furnished geological reports to the Victorian Secretary for Mines, collected botanical specimens for the Government Botanist, von Mueller, studied the customs and religions of the aborigines. His books, 'Kumlaroi and Kurrai', and 'The Tribes of South-East Australia', record this anthropological work. He became a member of the Royal Society of Victoria 1876 and contributed many papers to the Proceedings. In connection with his drawings, it is interesting to note that Eugene von Guérard, well-known landscape painter and first Director of the National Gallery of Victoria, was a friend of Howitt's and his companion, at times, on exploratory travels in the East Gippsland area. Other friends and associates were Sir Baldwin Spencer, who recognized the prime value of his anthropological work, and Baron von Mueller, to whom he sent botanical specimens. In 1899 he was appointed Victorian Secretary for Mines, and lived briefly in Melbourne, until 1901. He visited England 1902-3, and after this returned to Metung.

In his later years, Howitt received many honours: honorary Doctorates of Science from both Cambridge and Melbourne Universities; a Fellowship of the Royal Anthropological Society; C.M.G. in the Birthday Honours, 1906; the Clark Medal presented by the Royal Society of New South Wales; the von Mueller Medal presented, inaugurally, by the Australian Association for the Advancement of Science.

We still acknowledge him today. Apart from Mount Howitt in Gippsland, which bears his name, a proposed new water storage planned by the Victorian State Rivers and Water Supply Commission on the Mitchell River is to be named Lake Howitt. During 1969 Melbourne University Press will publish a book on Howitt's life, written by his grand-daughter, Mrs. Mary Howitt-Walker, who lives at Lakes Entrance. Contributions to this publication will be made by two members of the Royal Society of Victoria: Mr. John Mulvaney of Australian National University, and Dr. John Talent who writes also, in this Symposium, on the Geology of East Gippsland.

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G.M.

1

ASPECTS OF EXPLORATION AND SETTLEMENT OF EAST GIPPSLAND

By N. A. WAKEFIELD
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Abstract

Captain James Cook's observations of 20 April 1770 are summarized, controversy that has arisen from them discussed, and opinions expressed as to the identity of features which he named. A summary is given of George Bass's observations along the East Gippsland coast in December 1797 and January 1798.

It is shown that the Monaro Plains of south-eastern New South Wales provided a natural corridor for land explorers to reach East Gippsland, and later pastoralists with their cattle. Details are given of the discovery of the Omeo Plains by McKillop in 1835 and the depasturing of cattle there by early 1836, of the establishment of an out-station at Tubbut by early 1839, and of an excursion by McMillan to the Buchan area in 1839, followed by the taking up of a run there in early 1840. Some claims to penetration with cattle to the Gippsland Lakes in 1837 or 1839 are refuted. Details are given of the early occupancy of Suggan Buggan, and of the establishment at Wulgulmerang, by the O'Rourke family in about early 1845, of the first permanent homes in the Snowy River district of East Gippsland. The history of early occupancy of the Genoa River district of East Gippsland is outlined, with details of a licence for a cattle run at Wangarabell in 1839, of the use of the Genoa area in 1840, and of an unsuccessful settlement at Mallacoota in 1842.

An appendix lists data, obtained from the New South Wales State Archives, of depasturing licences for runs in and near East Gippsland. This data appears to have been overlooked by others writing about the history of Gippsland. A second appendix summarizes data of runs held in 1848 and 1850, and a third gives extracts of correspondence pertaining to these runs from files held by the Victorian Lands Department.

It is noted that a number of historical articles about East Gippsland contain unsubstantiated statements and factual errors, and it is suggested that statements should be regarded as valid only when acceptable authorities and references are available for them.

1. Introduction

Physiographically, East Gippsland is a continuation of south-eastern New South Wales. (Fig. 1.) The Snowy Mountains, with many ranges between 5,000 and 7,000 ft above sea level, run approximately N.-S. from Australian Capital Territory to the Cobberas Mountains area of East Gippsland. The near-coastal lowlands of East Gippsland and of south-eastern New South Wales rise abruptly, some 30 miles inland, to the Coast Range which, at 3,000 to 4,000 ft elevation, is only slightly higher than the country inland from it.

Between the Snowy Mountains and the Coast Range lie the Monaro Plains, a tract approximately 50 miles wide of undulating subalpine tableland, with a general elevation between 2,500 and 3,500 ft. In the vicinity of Cooma, the 'Dividing Range' is not recognizable to the eye in the wide expanse of tableland, so the plains extend without interruption from the Murrumbidgee River watershed to that of the Snowy River. These plains have their southern limits in the vicinity of Bendoc in East Gippsland, and, though cut off by the Snowy River valley, the Wulgulmerang Plateau too is essentially part of the same system.

The Monaro Plains were lightly forested and well grassed, and they provided a natural corridor by which grazing interests extended from the Goulburn district

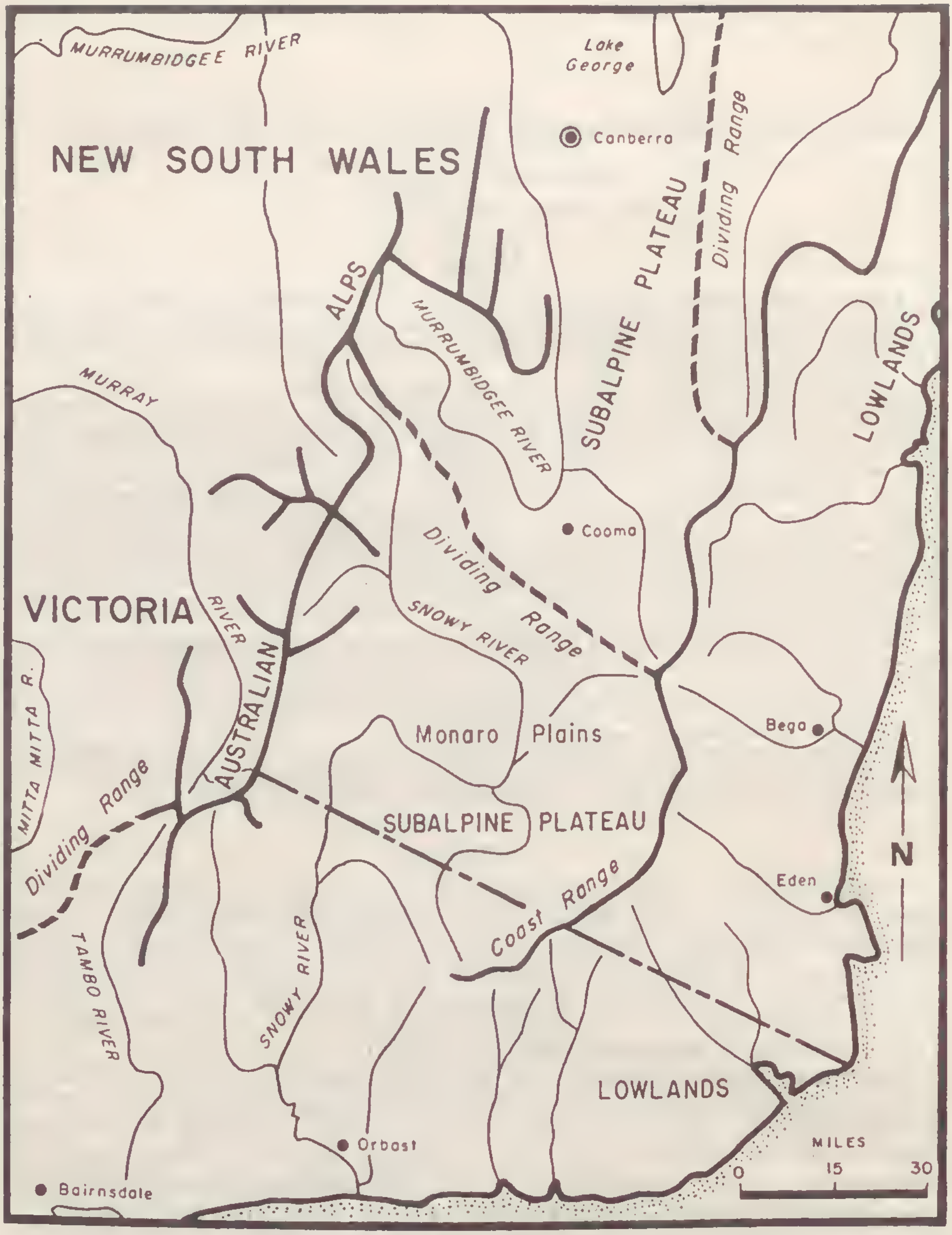

FIG. 1—Topographical relationship of East Gippsland and south-eastern New South Wales.

of N.S.W., via the Cooma district, to Gippsland. W. Odell Raymond, in a report dated 15 August 1853, described how he and others took large numbers of sheep and cattle by this route from Monaro to Gippsland in 1842 (Bride 1898, pp. 129-134).

During the preparation of the present paper it became evident that much that has been published on the history of East Gippsland is erroneous or of doubtful authenticity. This has been due to the acceptance by historians of unconfirmed reports and newspaper articles which do not cite authorities for statements, and to the incorporation of data from these sources in journals which enjoy some prestige. Material of this kind, much of which is now questioned or refuted, was used in a previous paper on the history of Gippsland (Wakefield 1951).

Historical societies were formed recently at Orbost and Bairnsdale, and secondary schools in those areas are now taking considerable interest in the early history of East Gippsland. For these reasons there is discussion in the present paper of certain newspaper articles and other trivial publications, as these sources are used by students and others endeavouring to compile historical information. It is intended that this paper should provide a basis for the evaluation of such data.

In this paper, unconfirmed reports have been discounted, though it is likely that some of these will eventually prove to be valid. The necessity for this principle is evident when it is noted, for example, that the claims of Hutton and Bayliss were for the most part untrue (Section 3(d)), that E. J. O'Rourke was in error regarding his grandfather's history (Section 4(b)), and that John Cameron's history of Maramingo contained gross error (Section 5(c)).

2. Coastal Exploration

(a) JAMES COOK, 1770

Observations recorded by Captain James Cook, in connection with the sighting of the coast and mountains of East Gippsland in April 1770, are summarized, from Wolskel (1941), as follows:

6 a.m. Sighted land extending from NE to W at distance 5 or 6 leagues.

Continued standing to westward until 8 a.m., then bore away NE, being at this time in latitude of 37° 58′ S and in the longitude 210° 39′ W. The southernmost point of land we had in sight which bore from us W¼S I judged to lay in the latitude 38° 0′ S and in the longitude 211° 07′ W from the Meridian of Greenwich. I named it Point Hicks, because Lieut^{t} Hicks was the first who discovered this land.

At noon we were in Lat. 37° 50′, Long. 210° 29′ W, 'the extremes of land extending from NW to ENE, a remarkable Point bore N 20° East distant 4 leagues. This point rises to a round hillock very like the *Ram Head* going into Plymouth Sound on which account I called it by the same name. Lat. 37° 39′, Long. 210° 22′.'

Magnetic variation, 8° 7′ E.

At 6 p.m. brought to for the night. Northernmost land in sight bore N by E. ¼E, and a small island close to a point on the main bore W, distance 2 leagues. This point, named Cape Howe, was identified by coast trending N on one side and SW on other, and also by round hills just within it.

Fig. 2 is a copy of part of one of Cook's charts of the south-eastern Australian coastline, published by the British Government in 1789 and reproduced by King (1892). The actual coastline has been superimposed.

The nautical day began at noon, when observations were made to allow the ship's position to be determined. Record was then made of compass readings and estimated speeds, so that the course for the ensuing 24 hours could be plotted. Computations and plotting were done later in the voyage, or after it.

Fowler (1907) pointed out that the date of the observations which are recorded here was actually 20 April 1770.

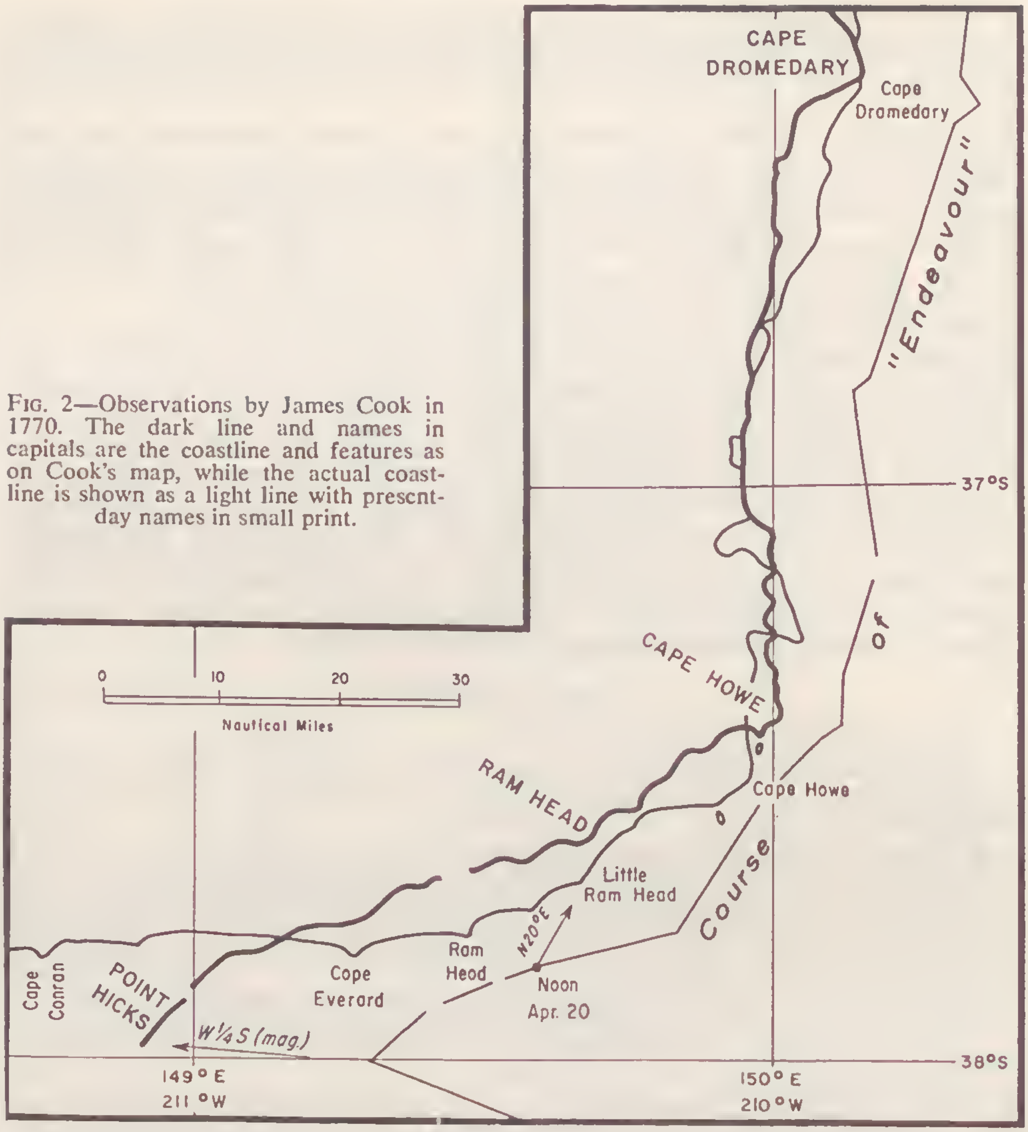

Fig. 2—Observations by James Cook in 1770. The dark line and names in capitals are the coastline and features as on Cook's map, while the actual coastline is shown as a light line with present-day names in small print.

From about Cape Everard to Twofold Bay, Cook's map places the coast north of its actual position by from 3′ to 8′ of latitude. Further north, at Cape Dromedary, the discrepancy is only slight.

The direction recorded for the observation of Point Hicks (W¼S) is a magnetic bearing of approximately 267°, equivalent to a true bearing of 275°, or 5° N. of W. The longitude given (211° 07′) was evidently calculated from an estimation of the distance of the point from the *Endeavour* when the observation was made.

Fowler (loc. cit.) comments: 'The position is in 50 fathoms water, and over 12 nautical miles from the nearest shore', and he concludes, 'The observation was faulty, the compass was in error, or a bank of clouds was mistaken for land.'

From the noon position of 37° 50′S. 210° 29′W. the point which Cook named Ram Head lay 20° E. of N. This appears to be a compass reading of NNE. corrected by the magnetic variation. As noted by Fowler (loc. cit.), 'the description seems to better suit the point now called Little Ram Head, which is only three miles from the position assigned by Cook, the discrepancy being about equal in amount and in the same direction as between Cook's position of Cape Howe and the present accepted position of the same'.

What is now known as Ram Head lies at 37° 46′S. and 149° 29′E., about 12 land miles from the position given by Cook, and it is W. of N. of the noon position of the *Endeavour*.

Scott (1912) argued at length that Cape Everard and Point Hicks were the same. He contended that Cook's expression 'I judged to lay', 'clearly represented a guess, probably made when writing up the journal afterwards', and he was very critical of Fowler's suggestion that Cook could have been in error in his observations. However, the preciseness of the position which Cook gave for Point Hicks does not support the contention that this was a guess. Fowler's three alternatives, to explain Cook's location of Point Hicks, appear to be logical and comprehensive.

In considering the accuracy of Cook's records, it must be remarked that he noted that the 'northernmost land in sight' from the anchorage 2 leagues E. of Gabo Island was 'N. by E. ½E.' (Wolskel loc. cit.), which is a magnetic bearing of 17°, or a true bearing of 25°. That was certainly an erroneous observation. To identify the original 'Ram Head' with the present Little Ram Head, and to place 'Point Hicks' at or near Cape Conran, would indicate only minor discrepancies in Cook's data. But to accept that Ram Head is correctly identified today, or to identify Cape Everard as Point Hicks, would presume gross errors in Cook's records. (See Fig. 2).

(b) GEORGE BASS, 1797-8

Except for the final paragraph, which comprises the author's observations, this section is derived from Bass's journal, published in Bladen (1895).

On 21 December 1797, George Bass and the crew of his whaleboat 'landed at a little beach about a mile north of the Ram Head'. A south-westerly gale kept them there for ten days, the boat 'lay off at anchor in a place where, though a swell came in, no breaking-water could'. Bass explored the area and recorded these observations:

> The country here is in general low, sandy, and not without lagoons, yet in figure hilly, but the hills are little else than sand; they have indeed a patched covering of green which might deceive the eye at a distance, but the usual sterility of the soil still prevails. The best I have been able to find is like what at Port Jackson is reckoned so favourable for potatoes, which is a mixture of sand with a very small proportion of vegetable earth.
>
> The general productions are short deformed gum-trees, tea-tree, some small shrubs, and patches of an almost impenetrable underwood of small brush, ground fern, and vines. The foliage of the underwood is rich and green, but the trees are far more dusky and brown than I have seen anywhere else. A luxuriant crop of grass may occasionally be found in places where the underwood has thinned off, but the soil is still the same. Where thick grass belly-high and fern plants are growing together one might expect better soil, but it is only a black sand like the rest.
>
> It is but very few miles that I have been able to penetrate into this close country, but by the sand patches, which when I ascended the Ram Head I could distinctly see peeping out of the sides of the black hills, I can conclude no otherwise than that the soil to a great distance inland is equally poor as, if not worse than, that which I have already trodden over.
>
> There are here many little runs of excellent water that, draining out of the sandhills, trickle over the rocky spots at their feet or sink through the beaches into the sea.

The journey was resumed on 31 December, and for 'about 30 miles' Bass noted:

> The land all the way . . . nearly the same height as about Ram Head—in front, long beaches at the bottom of bights of no great depth, lying between low rocky projecting points—there might be about three of these in the whole distance; in the back land lay some short ridges of lumpy irregular hills at a little distance from the sea.

On 1 January 1798 the craft travelled about 30 to 36 miles along the Ninety Mile Beach, which Bass described thus:

> The land in the whole of this distance was nothing but low beach—a very small hummock appeared indeed every now and then inland. There were many large smokes behind the beach, as we conjectured by the sides of lagoons, of which there was reason to believe the back country was full.

Later, Bass mentioned 'what is called Point Hicks, a point we could not at all distinguish from the rest of the beach'.

What Bass identified as Ram Head is the feature which has that name today. The whaleboat anchorage is a tiny sheltered cove at the westernmost end of the sand bar which separates Wingan Inlet from the ocean; it is protected on the seaward side by a little rocky peninsula. Much of the 'underwood' that Bass encountered was Lilly-pilly (*Eugenia smithii*) which in the vicinity of Ram Head forms extensive wind-pruned thickets only a few feet high. The main vine was Austral Sarsaparilla (*Smilax australis*).

3. **Land Exploration**

(a) CURRIE AND OVENS, 1823

The Monaro Plains of south-eastern New South Wales were discovered in mid-1823, by Captain Mark Currie, R.N. He set out southerly from Lake George, in company with Brigade-Major Ovens. On 6 June, they turned back, having reached a point a few miles from the present site of Cooma. Currie named the area 'Brisbane Downs' and noted that it was called 'Manaroo' by the natives. (Currie 1825). The party crossed the Umaralla River, which Currie's map identified as the Murrumbidgee.

(b) GEORGE MCKILLOP, 1835

Following the discovery by Currie and Ovens, cattle runs were established over much of Monaro during the 1820's and 1830's. The Twofold Bay area was occupied during the same period.

Lhotsky (1834) reported making an excursion from Matong (a station near Dalgety, Monaro) to the Australian Alps, where, on 6 March, he ascended a mountain 'from 5 to 7,000 feet' high and from which, he claimed, he 'discovered towards the SSW a very extensive plain, called by the natives Omeo'. The bearing given suggests that Lhotsky did not actually sight the Omeo Plain. It is more likely that he positioned the plain from the report of the aborigine who told him that 'it contained a lake, bigger than Lake George'.

In 1835, George McKillop and party explored south-westerly from Monaro to the Omeo area. His party 'ascended the sea-side range' at the sources of the Mitta Mitta, and 'saw the sea at a distance of 25 to 35 miles, a low scrubby forest intervening'. These details are summarized from Greig (1912) who cited as his authority 'a paper which (McKillop) sent to the Edinburgh *Journal of Agriculture* in February 1836 (and which was published in Vol. VII; pp. 156-169)'.

McKillop's report stated further that, since his visit, cattle had been sent to

Omeo from Monaro. Bonwick (1883, p. 488) stated that Macfarlane and Livingstone were members of McKillop's party, and that 'Livingstone afterwards formed a station upon the river called after him'. This evidently refers to Livingstone Creek, Omeo, but Angus McMillan's letter (Bonwick, loc. cit.) makes it clear that it was Macfarlane who sent cattle to Omeo from Monaro. (See also Section 3(c) and licence for 11 September 1839 in Appendix 1.) Hansford (1927) added to Bonwick's error by stating that all three—McKillop, Livingstone and Macfarlane—'settled in the Omeo area'.

(c) ANGUS McMILLAN, 1839

McMillan and his aboriginal guide, Jemmy Gibber, left Macfarlane's Currawong station on 28 May 1839, and travelled to Tubbut, an outstation of Moore's establishment at Burnima (see Fig. 3 and Appendix 3). They went on, evidently by way of the Deddick River, to cross the Snowy River next day. On 30 May they travelled an estimated 16 miles SSW., through 'fine open country', and on 31 May for a further 15 miles SSW. amongst 'high steep ranges'. On 1 June the distance was eight miles over steep broken country with dense scrub; and on 2 June a more westerly course was taken for seven miles 'over a fearful country'. Next day McMillan ascended a feature which he later referred to as Mount Macleod. On 4 June he travelled six miles NW. to 'a stream running into the Snowy', and thereafter proceeded northerly and reached the Omeo road on 9 June. He followed the road westerly and reached Omeo on 11 June. He found three settlers at Omeo: Macfarlane, Pendergast and Hyland. (These details are from Shillinglaw (1874), who quoted McMillan's diary records at length.)

McMillan's 'fine open country' of 30 May would have been the Wulgulmerang area, and on 31 May the route would have been through what is now Gelantipy. If the compass bearings which he noted in his diary are correct, they would not have taken him to the present Mount McLeod, which lies due S. of the Wulgulmerang area.

(d) CLAIMS BY HUTTON AND BAYLISS

McMillan stated, in a letter dated 8 February 1856 and quoted by Bonwick (1883, p. 494) that 'there was a station formed by Mr. R. Wilkinson at Buchan in April 1839' and that 'Buchan was first discovered by Mr. Baylop (sic) in the beginning of the year 1839'.

Skene and Smyth (1874) recorded the following story, given to Alfred W. Howitt, Police Magistrate of Gippsland, by Andrew Hutton, on 17 February 1874:

> Andrew Hutton travelled in 1838 from Nungatta on the Genoa River to the entrance of the lakes with 500 head of cattle and five men. They travelled along the coast, crossing the mouth of the Snowy River. They stayed at the entrance about a week, the natives hunting the party all the time, and finally driving them away and killing the cattle.
>
> Wilkinson took up Buchan with 100 head of cattle immediately before McMillan came down. About the same time McIntyre took up Gelantipy, also before McMillan arrived.
>
> When Hutton was hunted away from the entrance, at the time of his first arrival, he found the wreck of the schooner *Shaw*, trading from Sydney to Hobart Town. He buried four or five of the sailors. This was near the Wingan River.

Shillinglaw (loc. cit.) outlined McMillan's and Strzelecki's exploratory work. He quoted the report which Hutton had given Howitt, but with the comment, 'So much for the claims of Andrew Hutton'. A week later, Edward Bayliss replied with a letter (Bayliss 1874) containing the following statements:

> I was the first person who opened up that district, in the month of October, 1838.
> I started from Aston, Maneroo, . . . made my way to the Ninety Mile Beach, and camped on what is now Ewing's Swamp on the 1st day of November. On the Sunday morning, the 2nd, I walked over the entrance of the lakes, at Jemmy's Point, as it is now named. I . . . returned to Buchan, marked out that as a temporary station, and returned to Maneroo, ...
> In February, 1839, I again started for Gippsland, with 715 head of cattle, two drays, and eight men, for building, fencing, etc. I found Wilkinson a day ahead of me, with a few of Mr. F. Mouatt's cattle. I therefore took up Callantipy, and formed that station in March, 1839, and long before M'Millan left Maneroo. My old stockman, E. Bath, was induced to leave me by an offer of higher wages from M'Millan, and that man and my blackfellow, Jemmy Gibbie, showed them the way down several months later. Now for Andrew Hutton's statement. This man . . . was engaged by me in January 1830 (sic) to go down with the cattle and take charge of them when there. However, the engagement was not matured, but I heard that an attempt had been made to take cattle down the coast in 1839 . . . In my muster at Callantipy, in July, I recovered 19 bullocks for them, and sent them into Maneroo.

Greig (loc. cit.), on the authority of 'rev. Geo. Cox (from recollections of Mr. Chas Lucas)', added these details to the Hutton story:

> Hutton was employed by Morris, owner of Nungatta Station, and accompanied him in three successive years, on exploratory trips to the south-west. On the first two, progress was blocked by the Snowy River, and on the third they took 500 cattle to the Gippsland Lakes. A man named Wood had gone ahead by boat to Shallow Inlet, with supplies, but returned after waiting there for six weeks.

In connection with the Hutton story, the present author makes these comments:

(i) Wm. M. Morris, resident in the Moruya area, was extending his interests from Moruya to Genoa up until 1840 (see Appendix 1).

(ii) The mouth and estuary of the Snowy River were deep and were navigated by coastal trading vessels until 50 years ago. It is highly improbable that cattle could have been crossed there, and it is even more improbable that a pastoralist would have attempted to take cattle into unexplored country. (Shallow Inlet is 150 miles westerly from the Snowy River.)

(iii) The schooner *Schah* was wrecked, with loss of life, two miles east of Ram Head, on the night of 20 December 1837. After covering two of the dead, A. W. Milligan, the first officer, and the survivors set out overland for Twofold Bay, which they reached on 29 December. (Milligan, 1838). Milligan's report does not mention Hutton's party.

(iv) Taylor (1866) made no mention of the Hutton expeditions (Section 4(c)).

Apart from the improbability of much of Bayliss's story, there are these specific points:

(i) In 1838, 2 November was a Friday.

(ii) Ewing's Morass is east of Lake Tyers and, at its nearest point, is at least four miles from the original entrance of the Gippsland Lakes and over nine miles from Jemmy's Point.

(iii) Wilkinson held Buchan in his own right until 1842, when Mowatt acquired it. (see Appendix 1.)

(iv) Gibber was McMillan's sole companion on the excursion to the Buchan area in 1839 (see Section 3(c)), and Edward Bath accompanied him into central Gippsland in 1840 (Bonwick loc. cit.).

(v) Bayliss's timing would place Hutton's supposed Gippsland Lakes expedition more than a year later than the wreck of the *Schah*.

McMillan made no mention, in the reports of his 1839 excursion through the Gelantipy and Buchan areas, of any sign of cattle there. If his information to Bonwick (loc. cit.) was based on claims made by Bayliss, then it is highly suspect.

If the location of the run obtained by Bayliss in September 1839 were determined (see Appendix 1), it might throw light on this matter.

On data available during this study, it would appear that, while Bayliss may have discovered Buchan sometime in 1839, the later claims of both Bayliss and Hutton to penetration with cattle to the Gippsland Lakes area in 1839 or before are untrue.

4. **Settlement in Snowy River District**

(a) EARLY RUNS

None of the three settlers whom McMillan reported to be at Omeo in June 1839 (Section 3(c)) did, in fact, have his home there. Macfarlane resided at Inverlochy, near Goulburn, and his 1839 licence was for 'Currawong and Omeo' (Appendix 1). In 1854 the buildings on his Omeo run were still only huts (Appendix 3). Evidently, Pendergast and Hyland both regarded their use of the Omeo area as auxiliary to main interests in N.S.W., for neither mentioned Omeo in connection with their early licences (Appendix 1).

Tubbut was an auxiliary of Moore's run at Burnima, N.S.W., from about late 1838 to 1852, when Whitakers acquired it to establish a family home there (Appendix 3). Campbell's 1839 licence included Delegate, and this run probably extended into East Gippsland at that time (Appendixes 1 and 2). Wilkinson's licence for Buchan in January 1840, and Hensleigh's for Bendock in June 1842 (Appendix 1), were the first to be obtained for runs in the Snowy River district of East Gippsland. Gelantipy was evidently used by Hughes and McIntyre of Gunningrach, N.S.W., from about 1843 onward (Appendix 3).

Buchan (*A. W. Howitt, 1876.*)

(b) Suggan Buggan and Wulgulmerang

Due apparently to misinterpretation of statements in letters in Lands Department files (Appendix 3) and to incorrect data on a gravestone, an erroneous history has come to be accepted concerning early settlement in the Suggan Buggan and Wulgulmerang areas.

For example, a newspaper article stated that Edward O'Rourke settled at Suggan Buggan in 1838, and his brothers, James and Christopher, settled at Black Mountain and Wulgulmerang ('N.B.' 1948). Edward was, in fact, a son of James, and in 1838 he was about nine years old (this section, below). James O'Rourke's statement in 1848, that he had been a licensed payee in the District of Monaro for ten years (Appendix 3), referred mainly to his licence for Countegany, near Cooma (Appendix 1).

In another newspaper article, E. J. O'Rourke, son of Edward, stated that James O'Rourke moved to Black Mountain in 1840, where he resided for some time before shifting to Wulgulmerang. He stated further that Black Mountain had been occupied previously by Richard Brooks and that 'Hugden' occupied Suggan Buggan before Woodhouse. (O'Rourke, 1936). The first statement is contradicted by James O'Rourke's information to J. J. Hedley (Appendix 3); no depasturing licence was found in the name of Hugden; and the only indication that was found of an interest by Richard Brooks in this district was his tenancy of the Willis run in 1848 (Appendix 2).

Edward O'Rourke's statement, dated 13 April 1868, that his improvements had been at Suggan Buggan for 20 years (Appendix 3), would have referred to the 'Forest Paddock' on the Wulgulmerang Plateau, which, though not in the Suggan Buggan valley, was included in O'Rourke's Suggan Buggan run (see this section, below).

The first licence for Suggan Buggan, that for the year 1842-43, was issued to William Woodhouse in April 1843 (Appendix 1), and Victorian Lands Department records (Appendix 3) show that it passed through the hands of Kesterton and McGuffie before Edward O'Rourke first obtained it in January 1858. Additional details have been provided by the General Drafting Branch, Department of Lands, Sydney (letter, 1 August 1961), as follows:

> Licence . . . held by William Woodhouse between 1842 and 1845; in 1845 . . . by Benjamin Boyd. In 1849 the lease was transferred to William Sprott Boyd. It was subsequently acquired by Samuel Browning and transferred by him to Alexander Campbell in 1851. In 1852 it was transferred to John Henry Challis.

Information regarding early settlement in the Wulgulmerang area was obtained from F. Smyth and K. Daniel (pers. comm. 1967), grand-daughters of David O'Rourke, Jnr., a son of Christopher O'Rourke, Snr. This is the authority for statements in the remainder of this section relating to O'Rourke family history.

James O'Rourke's home was at Wulgulmerang from about early 1845 until 1852 (Appendix 3), after which he removed to the Yarram area of South Gippsland.

Christopher O'Rourke, Snr., younger brother of James, made his home at Black Mountain, on the north side of the Little River, also about early 1845, when his second son, David, was two years old. He died in 1854, aged 44. (The stone on his grave at Black Mountain was made in Bairnsdale with year and age incorrectly inscribed as 1844 and 54 respectively.) At the time of Christopher's death, his sons, John and David, were aged about 14 and 12 years respectively.

Edward, eldest son of James O'Rourke, returned to the district and managed the Little River run for a number of years before acquiring the Suggan Buggan run in January 1858.

Christopher, Jnr., second son of James O'Rourke, acquired Wulgulmerang in February 1859 (Appendix 3) and made his home there. (Letters in the Wulgulmerang file, Lands Department, Melbourne, incorrectly refer to John and Christopher, Jnr., as brothers.)

In August 1859, John O'Rourke was granted Little River as a new run (Appendix 3). It had been occupied without licence for the 14 years prior to that date. He resided there until 1868, when he removed to the Wulgulmerang run, from which he retired to Bairnsdale in 1909. (Little River run later became known as Black Mountain.)

Edward O'Rourke removed from Suggan Buggan to Benambra in about 1884 but continued to run cattle on Suggan Buggan. He died at the 'Forest Paddock' of the Suggan Buggan run, in 1902, aged 73, and was buried at Black Mountain.

There was also a David O'Rourke, Snr., brother of James, who lived in the Wulgulmerang area for some time. He died at Appin, N.S.W., in 1855.

David O'Rourke, Jnr., had a house on part of the Wulgulmerang run until 1867, when he removed it to the south side of the Little River at Black Mountain, where he resided until 1879, when he removed to Buchan.

The brothers James and Christopher O'Rourke, coming to the Wulgulmerang area in about early 1845, were the first settlers to establish permanent family homes in the Snowy River area of East Gippsland.

(c) ORBOST AREA

Cameron (1926) stated that Peter Imlay occupied Orbost with 800 head of cattle from Monaro but abandoned the locality after trouble with the blacks, and that N. and J. Macleod succeeded him there.

An anonymous historical article, in a booklet printed in Orbost in 1937, stated:

> As far as can be gathered the first settlement in the Orbost District took place in 1842 when Mr. Peter Imlay brought cattle from New South Wales and settled on the eastern side of the Snowy River where the Orbost township now stands. Peter left Monaro with 800 head of cattle and travelled down Cann Valley and crossed the Lower Bemm.

Neither Cameron nor this anonymous writer substantiated their statements in any way.

The depasturing licences in the name of Peter Imlay in the early 1840's were for Bega and Walumla (Appendix 1), and no evidence was found that he had interests at any time in the Snowy River area.

Norman Taylor, after spending several months in close association with the pioneers of the Genoa district, stated that 'no one has ever been across from the Cann to the Snowy River, except along the coast, and the party that did that lost all their horses, and were all but starved'. (Taylor loc. cit.) He made no mention of cattle being taken to the lower Snowy River or beyond.

Norman and John Macleod, who held the first licences for runs in the Orbost area (Newmerella and Orbost, respectively) each stated that the date from which he had held the licence was 1 July 1847 (Appendix 3). This does not necessarily mean that they occupied these runs on that date. Depasturing licences were issued for the whole of the financial year and dated as from 1 July, irrespective of the actual date of occupation of a run.

The anonymous historical article mentioned above (printed Orbost, 1937) stated further:

From official files it is found that in 1845 Grazing Area No. 34 Orbost was held by Arch Macleod and carried 800 cattle. At the same time Grazing Area No. 33, 16,000 acres at Newmerella or Lochend, was held by the same people and carried 500 cattle and 2,000 sheep.

The numbers 33 and 34 are those allotted to these runs in the N.S.W. *Government Gazette* of 13 September 1848. The date '1845' is evidently a mistake for 1848, and the 'Arch Macleod' is an error also (See data in Appendixes 2 and 3). Furthermore, the numbers of cattle and sheep given here were merely those noted in the *Gazette* under the heading 'estimated capacity', not actual stock on the respective runs.

5. **Settlement in Genoa River District**

(a) WANGRABELLE

The first depasturing licence for an East Gippsland run was that for Wangrabelle, issued to John Stevenson in November 1839 (Appendix 1). Stevenson retained this run for at least 11 years (Appendix 3).

Details of stations and residents in the Genoa River district are given in a book by an ex-convict, Joseph Lingard, who travelled through the area in about August 1842. At that time, a family named Donald was in residence at Wangrabelle. (Lingard, date unknown.)

(b) GENOA

Wm. F. Morris held Nungatta and Genoa for the year 1840-41 (Appendix 1), and Greig (loc. cit.) stated that Morris sold to 'Abercrombie'. However, no depasturing licence was found either in the name of Morris or Abercrombie for the period 1842 to 1846.

A map prepared by F. P. MacCabe in February 1847 (now held by Lands Department, Melbourne) shows two paddocks on the south side of the river about where Genoa is now located, labelled 'Campbell's Cattle Station'. A depasturing licence was issued to Campbell and Co. on 25 September 1846, which, though specifying Gundary only, presumably covered Nungatta and Genoa as well (See Appendix 1, licence for 14 August 1840).

(c) MARAMINGO

Cameron (loc. cit.) set out details about Maramingo: Taken up by Robert Greig about 1841, sold to T. Doyle, sold to A. Weatherhead in 1847, sold to J. Allan in 1850-51 when Weatherhead bought Nungatta.

The present investigation has not ascertained whether Maramingo was in fact the identity of 'Mirimalka' (or 'Mirunalka'), a licence for which was issued to Robert Greig in January 1841 (Appendix 1). No record was found of a depasturing licence held by Greig between 1841 and 1846, and neither Maramingo nor 'Mirimalka' was amongst the runs listed in the N.S.W. *Government Gazette* of 1848 or 1850.

Lingard (loc. cit.) found 'a station on each side of the river' at Genoa in about August 1842, and MacCabe's Genoa River map of February 1847 has 'Js. Allan's House' and 'Shannon's Cattle Station hereabouts' marked in the Maramingo area, directly across the river from the Genoa paddocks. Taylor (loc. cit.) referred to Allan's home at the same place. Campbell's reference to Genoa having 'no neighbours' (Appendix 3) appears to have been erroneous.

Cameron was in error in some details. Maramingo was applied for by

Weatherhead in April 1853 (Appendix 3), and Weatherhead (1891) indicated that he bought and occupied Nungatta in 1859. (However, Weatherhead lived at Nungatta as overseer during an earlier period; he was there when Lingard visited the area in 1842.)

(d) MALLACOOTA

Greig (loc. cit.) made two statements about the settlement of Mallacoota. The first quoted letters in the Melbourne newspaper, *The Argus* (25 May and 28 May 1909) which said that Mallacoota 'was settled previous to the Messrs. Henty Brothers' arrival at Portland towards the close of 1834', and that 'the settler's name was Stevenson—an ex-ship master—and his homestead was at what is still known locally as Captain's Point'. The second stated that 'the year 1842 saw the location, at Mallacoota Inlet . . . of an ex-whaler named John Stevenson, who had been in the employ of Benjamin Boyd, of Twofold Bay'. For this second statement, Greig gave as authority 'Mr. J. M. Reid, to whom it was communicated by Mr. Wm. Allan, grandson of Captain Stevenson'.

Cameron (loc. cit.) stated that Stevenson arrived at Twofold Bay in 1836 in the Brig *Horn*, a Greenland whaler, with Robert Greig as First Mate.

Benjamin Boyd arrived in Australia on 18 July 1842 and resided in Sydney. He made only infrequent visits to Twofold Bay, and the whaling operations carried on there in his name were from 1843 to 1848. (Wellings, date unknown.)

Lingard (loc. cit.) indicates that, in about July 1842, he met Stevenson, who 'had formed a station near Cape Howe', and 'he and his family had been there about three months'. The station was later identified as Mallacoota. Lingard travelled from Bondi to Mallacoota where he stayed until the late spring of 1842. Living in 'two huts made with bark and covered with bark, . . . close to the beach', were the Stevenson family and a second family. This settlement was later abandoned, for MacCabe's map bears the inscription 'An abandoned Cattle Station' at the site of Mallacoota.

Stevenson's huts would have been those mentioned by S. C. Johnson as having been occupied by William Baird (Appendix 3). Billis and Kenyon (1932) stated that Baird was at Mallacoota from 1850 to 1854.

Summary

James Cook's recorded observations of the East Gippsland coast on 20 April 1770 do not justify the identification of his 'Point Hicks' with Cape Everard, and his 'Ram Head' appears to be the feature now called Little Ram Head. George Bass's journal of December 1797 records observations of vegetation and soil about Wingan Inlet, and, while he identified the present Ram Head as Cook's Ram Head, Bass failed to distinguish any feature as Point Hicks.

In 1823, Currie and Ovens discovered the Monaro district, and by 1840 cattle were depastured across these plains and into parts of East Gippsland. James Macfarlane sent cattle to Omeo soon after its discovery by George McKillop in July 1835. Tubbut was in use as an out-station of Thomas Moore's Burnima run in early 1839, when Angus McMillan penetrated the Buchan area; John Wilkinson obtained a licence for the Buchan run in January 1840; John Hensleigh obtained a licence for the Bendock run in June 1842; and Hughes and McIntyre used Gelantipy from about 1843 onward, as an out-station of their run at Gunningrach, N.S.W.

The first grazing licence for the Suggan Buggan run was taken out in April 1843 by William Woodhouse, and this run changed hands several times before

Edward O'Rourke obtained it in January 1858 and established a home there. The brothers James and Christopher O'Rourke were the first permanent settlers in the Snowy River area of East Gippsland; they established family homes at Wulgulmerang and Black Mountain in about early 1845. Christopher died in 1854, not 1844 as his gravestone indicates. The first grazing licences for the Newmerella and Orbost runs were those obtained by Norman and John Macleod sometime between July 1847 and May 1848.

In the Genoa River valley, John Stevenson obtained a licence for the Wangarabell run in November 1839, and Genoa was used as an out-station of William Morris's Nungatta run in 1840. John Stevenson settled with his family at Mallacoota early in 1842 but had abandoned the site by February 1847. Maramingo was occupied prior to August 1842 but its early history is obscure.

Neither the claims that Andrew Hutton took cattle from Nungatta to the Gippsland Lakes in the late 1830's, nor the statement that Peter Imlay took cattle via the Cann River valley to Orbost in the early 1840's, is accepted as valid; and the claim that Edward Bayliss reached Buchan before Angus McMillan did is considered to be dubious.

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APPENDIX 1

Depasturing Licences, 1837 to 1846

Copies of depasturing licences issued from 1837 to 1846 are preserved in the New South Wales State Archives. They are bound, in chronological order, in 18 volumes. The first volume contains those for the year 1837-38. There is no record of any licences for 1838-39, and the set for 1840-41 may be incomplete. The last licences in the bound volumes are for the year 1845-46. Each volume containing licences issued between 1837 and 1844 contains an index of the licensees, but the several volumes of licences for 1845-46 are not indexed. Each licence was issued for a single financial year (ending 30 June) and the annual fee for each was £10.

Further information is contained in a letter received from the General Drafting Branch, Department of Lands, New South Wales, in August 1961, as follows:

> Although there was settlement in the Monaro district in the 1820's and 1830's, no official record exists until the Depasturing Licences of 1837 were issued. These licences gave no description of the location of runs and very often no run name. Licensees were required to indicate the situation of their holding within a particular district and it is under this heading that the run name, if any, is given.

Search was made through the indexes of the earlier volumes of the depasturing licences and data extracted about certain licensees, and all Monaro district licences for the year 1845-46 were perused. This method of search may have overlooked some relevant data of licences which changed hands between 1837 and 1845.

In many cases the place of residence of the licensee indicated that he did not live on the run for which the licence was issued. Furthermore, licences were sometimes held for short periods (possibly under some form of mortgage) by certain companies, and in these cases there is no indication of who actually occupied or used the runs concerned.

Billis and Kenyon (loc. cit.) published data of pastoral leases and lessees in the Port Phillip District (= Victoria). Their compilation was based almost wholly on records in the Victorian Department of Lands, Melbourne, and it lacks much relevant information that is available in the New South Wales State Archives.

Following are dates of issue and other data of licences which concern, directly or indirectly, the early history of East Gippsland:

21 February 1837. 'Snowey River'. Edward W. Bayliss of 'Snowey River'. (See also 24 September 1839.)

7 March 1837. Bergalia. Wm. F. Morris of Moruya. (This is Morris's only licence for this year. See also 1 November 1839 and 16 September 1839.)

11 March 1837. Monaro, location unspecified. Robert Campbell. (Same data 29 May 1838. Both licences probably apply to Mount Cooper only. See also 12 July 1839.)

3 August 1837. Monaro, location unspecified. Francis Mowatt of Narellan. (This may apply to Bollero. See 12 July 1842.)

15 February 1838. Appin. James O'Rourke. (This is his only licence for this year. See also 1 October 1839.)

8 June 1838. Monaro, location unspecified. John Pendergast of 'Monaro'. (See also 9 November 1839.)

19 June 1838. Monaro, location unspecified. Alexander Livingstone of 'Monaro'.

30 June 1838. Monaro, location unspecified. James Macfarlane of 'Inverlochy', Goulburn. (See also 10 September 1839.)
11 July 1839. Burnima. Thomas M. Morre. (His first licence.)
12 July 1839. Mount Cooper and Delegate. Robert Campbell. (See also 30 June 1840.)
20 July 1839. 'Boro Creek, Mowenbar' (= Moonbah). Thomas Hyland. (Same data for subsequent years.)
10 September 1839. 'Currawong and Omeo'. James Macfarlane of Inverlochy. (Same data, 1840-1843.)
13 September 1839. 'Biggah' (= Bega). Peter Imlay of 'Biggah'.
24 September 1839. 'Aston, near Mount Delegate'. Edward Lord of Sydney (Mortgager?).
24 September 1839. 'Beyangus' (?spelling). Edward W. Bayliss of Aston.
1 October 1839. Countegany. James O'Rourke of Countegany. (Same data for subsequent years. See also 23 September 1845.)
1 November 1839. Bergalia. John Hawdon of St. Vincent.
9 November 1839. Cottage Creek. John Pendergast of Cottage Creek. (Same data annually until 1842-43, except that residence was at Campbelltown in 1840-41.)
16 November 1839. Gundary and Nungatta. Wm. F. Morris of Gundary. (See also 14 August 1840.)
16 November 1839. Wangarabell. John Stevenson, of Twofold Bay. (Same data for 1841-42, except that no residence was stated. No licence recorded for Stevenson thereafter.)
30 January 1840. Buchan. John R. Wilkinson, giving residence as Buchan. (Same data up to year 1841-42 but with 'Murrindale' included in the last.)
29 June 1840. 'Gunigrali' (= Gunningrach). John Terry Hughes and John McIntyre of 'Gunigrali'.
30 June 1840. Delegate. Robert Campbell. (Mount Cooper not included. Same data for subsequent years.)
14 August 1840. Gundary, Nungatta, Genoa. Wm. F. Morris of 'Gundary on the Moruya'. (No subsequent licence in name of Morris.)
29 September 1840. 'Walamba' (= Walumla). Peter Imlay. (Same data for subsequent years.)
1 January 1841. 'Mirimalka' (?Maramingo). Robert Greig of 'Biggah' (= Bega). (No further licence in name of Greig or for 'Mirimalka'.)
29 February 1841. Bondi. Thomas Luscombe. (Same data for subsequent years.)
28 September 1841. Delegate. George Simpson. (Same data for subsequent years.)
27 June 1842. Bendock. John S. Hensleigh. (Same data for subsequent years.)
12 July 1842. Bollero and Buchan. Francis Mowatt of England. (Same data for two following years. See also 25 September 1845.)
29 September 1842. Craigie. Charles Lawson. (Same data for subsequent years.)
3 April 1843. Suggan Buggan. William Woodhouse of 'Snowy River'.
28 September 1844. Countegany. John Hawdon. (But see 23 September and 30 September 1845.)
23 September 1845. Countegany. James O'Rourke. (But see 30 September 1845.)
25 September 1845. Gundary. Campbell and Co.
25 September 1845. Buchan. Francis Mowatt.
25 September 1845. Willis. Francis Mowatt.
26 September 1845. Ingebyra. William Woodhouse. (His only licence for this year.)
30 September 1845. Countegany. John Hawdon. (But see also 23 September 1845.)
6 November 1845. Suggan Buggan. Benjamin Boyd.
20 November 1845. Jingalalla. Peter Taylor.

APPENDIX 2

Summary of Runs, 1848 and 1850

In the N.S.W. *Government Gazette* of 13 September 1848 there was a summary of pastoral leases, giving name of lessee, name of run, and description of boundaries. A supplementary list appeared in the N.S.W. *Government Gazette* of 6 April 1850. The boundaries were not surveyed, and the descriptions of them, in the *Gazettes* were simply quotes of details submitted by lessees with their applications for grazing rights. Fig. 3 shows the location of runs in East Gippsland at about that time, and some runs in adjoining regions.

FIG. 3—Location of runs in East Gippsland and some runs in adjoining regions, as in 1850. In each case the headquarters of the run was about where the centre of the name falls.

This appendix sets out data of runs, extracted from the *Gazettes*. The names of the runs (with modernized spelling)* are placed in alphabetical order, followed by the lessee in each case, then, in parenthesis, there is information about location or boundaries. The items in brackets are observations by the present author. Unless otherwise stated, the run was listed in the N.S.W. *Government Gazette* of September 1848.

BENDOCK. J. S. Hensleigh. (Between Campbell's Delegate run, Delegate Hill, Bendock River, and a NS. range to the east.)

BONDI. Benjamin Boyd. (Bounded on S. by 'Black Mountain or Coorambocombala'.) [This is the present Coopracambra Mountain in East Gippsland.]

BUCHAN. Archibald Macleod. (Snowy River on E., Boggy Creek on S., Wilkinson River on W., 'Black Mountains' on N.)

CRAIGIE. Charles Lawson. (A small portion extended into East Gippsland along the lower Bendock River.)

DELEGATE. Estate of late Robert Campbell. (One section, between Hayden's Bog and Mount Delegate, lay within East Gippsland.) ['Mr. Boyd's cattle station hut known as Kirkenong', is mentioned.]

DELEGATE. George Simpson. (Between Delegate Hill, Campbell's Delegate run, and Hensleigh's Bendock run.)

GELANTIPY. Hughes and McIntyre. (*Gazette* 1850.) (Watered by a creek known as Butchers Creek; Snowy River on E., range on S. dividing it from Mr. Scott's Buchan run, gully four miles from 'Wongollamerang' run on N.) [The 'gully' is Boundary Creek.]

GENOA. Wm. Campbell and Co. (*Gazette* 1850.) ('on a river of that name in a wild country, no neighbours'.)

JINGALALLA. Charles Lawson. (Between Moore's 'Tubbut' run and McLaughlin's run, with a swamp on S.) ['McLaughlin's run', is evidently Dellicknora, and Jingalalla is now named Cabanandra. (see Fig. 3).]

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* It will be noted that in the early settlement of East Gippsland (as even today) the spelling of place names was not standard. (*Ed.*)

[KIRKENONG, LITTLE RIVER, MALLACOOTA . . . not in either *Gazette*.]

NEWMERELLA or LOCHEND. Norman R. Macleod. (Snowy River on E., barren heathy ridges parallel with the Ninety Mile Beach on S., dense scrub running parallel to the Snowy River on W., black range known as the Haystack Mountain on N.) [The 'Haystack Mountain' is probably Mount Tara, 15 miles WNW. of Orbost, not Mount Macleod near Buchan which is sometimes referred to as the Haystack.]

ORBOST. John Macleod. (Brodribb River on E., Snowy River on S. and W., ranges about 15 miles below the Buchan River Junction on N.)

QUEENSBOROUGH. Benjamin Boyd. ('Nicholson's Bog' on E., Little River on W., Bendock River on N.) ['Nicholson's Bog' is evidently Craigie Bog.]

SUGGAN BUGGAN. Benjamin Boyd. (Ranges towards the 'Snow Mountains' on E., Black Mountain on S., 'Omeo Ranges' on W. and N.) ['Snow Mountain' is probably a mistake for Snowy River.]

[TUBBUTT, WANGARABELL . . . not in either *Gazette*.]

Persons more or less concerned in the history of East Gipsland were listed in the *Gazette* 1848 as having these runs:

Peter Imlay. Cobargo, Murrah and Double Creek (all in the Bega-Narooma area).
Francis Mowatt. Bolero (near Cooma).
John Pendergast. Cottage Creek (near Cooma), Moonbah (south of Jindabyne), and 'Homeo' (= Omeo).
William Whittakers. Tombong.

APPENDIX 3

Files in the Department of Lands, Melbourne

Further to data noted in Appendixes 1 and 2, the following details were extracted from files of correspondence held by the Victorian Department of Lands.

In 1847, run holders were requested to make formal application for leases, and on these there was usually a standard statement that the run had been occupied 'for 12 months previously', but this does not necessarily indicate the date of original occupancy.

BUCHAN. 31 December 1847. Applied for by Archibald Macleod of Bairnsdale.

GELANTIPY. 11 August 1848. John McIntyre stated that the station had been in the possession of Messrs. Hughes and McIntyre for 5 years and was included in the licence for Gunningrach, N.S.W. The description mentioned the 'Galantiby Hut', showing that the run was merely an outstation in 1848.

GENOA. 18 July 1853. Peter Imlay, as holder of the Genoa run, applied for its transfer to Robert Alexander.

LITTLE RIVER. 19 March 1859. Run applied for by John O'Rourke, described as 'bounded on E. by Sugan Bogan Black Range and the station of Edward Rourke . . . W. by Christopher Rourke's station named Wan Woologorang . . . S. by Snowy River . . . N. by falls from mountains'. (Note: In this description, the points of the compass have been rotated 90°, so the 'W' here is actually S., etc.)

MALLACOOTA. 23 May 1856. Application by S. C. Johnson for Mallacoota run, in which he described it as having 'a couple of huts and a stockyard'. He stated that it had been occupied by William Baird, an Otaheiteian, who had died in 1854.

MARAMINGO. 8 April 1853. Run applied for by Alexander Weatherhead of Eden. Boundaries were Genoa River on S. and W. and 'Tombillica River' (= Wallagaraugh River) on E.

NEWMERELLA or LOCHEND. 16 May 1848. Norman Macleod stated 'the precise period during which I have held licence for . . . Numeralla or Lochend . . . (is) from 1st July 1847'.

OMEO. 23 March 1848. In application for lease (Omeo A), John Pendergast gave his address as Campbelltown.

9 October 1854. W. Piper, Commissioner of Crown Lands, described the improvements (Omeo B, James Macfarlane's run) as 'the homestead of an original and entire run since the year 1849 consisting of two huts, stockyards, stables, garden, grazing and cultivation paddocks'.

ORBOST. 29 May 1848. John Macleod stated 'the precise period during which I have held a licence for my station called Orbost . . . is from the 1st of July 1847'.

SUGGAN BUGGAN. 31 December 1847. Application for run by Benjamin Boyd.

20 October 1856. Transfer from Henry Kesterton to James McGuffie.

22 January 1858. Transfer from McGuffie to Edward O'Rourke.

13 April 1868. Edward O'Rourke stated that his improvements had been at Suggan Buggan for 20 years.

TUBBUT. 7 October 1847. Thomas M. Moore of Burnima, N.S.W., stated that he had occupied the Tubbut run for the previous nine years. (This has led to the published statement (Hansford, loc. cit) that Moore took up the run in October 1838, but Moore's round figure of 'nine years' does not justify Hansford's precise dating of the month of original occupancy.)

18 October 1851. Moore stated that Burnima had been the head station, and that Tubbut and Amboyne were auxiliaries, the last a 'sheep station'.

30 October 1852. William Whittakers acquired the Tubbut run.

WANGARABELL. 24 October 1850. J. J. Tyers, Commissioner of Crown Lands, stated that John Stevenson had occupied the run, without taking out any licence, for the previous seven years. (See licence, 16 November 1839, in Appendix 1.)

WULGULMERANG. 25 June 1848. James O'Rourke applied for 'Woologoramang'.

12 August 1848. James O'Rourke stated that he had been a 'licensed payee in the District of Manero for a period of ten years'. (See licences for 15 February 1838 and for subsequent years, in Appendix 1.) The run was described as bounded by Snowy River to E., Mrs. Terry Hughes to W., Deep Creek mountains to N., scrub and barren ranges to S. (In this description also, the points of the compass are rotated 90°, as with the description of Little River, above.)

16 February 1852. Transfer from James O'Rourke to P. C. Buckley.

26 February 1859. Transfer to Christopher O'Rourke.

25 March 1860. J. J. Hedley, Commissioner of Crown Lands, stated, 'from the original occupant (i.e. James O'Rourke) I learn that the north boundary was a deep creek (south of the Little River) rising in the Native Dog Ranges and falling into the Little River before its junction with the Snowy River'. (The 'deep creek' is Wulgulmerang Creek.)

7 May 1860. J. J. Hedley stated, 'James Rourke, first licensee of Wulgulmerang, states that he never applied for nor occupied the country beyond the deep creek south of the Little River. He held the run seven years and then sold to Mr. P. C. Buckley. Buckley sold to Captain Jones who . . . never occupied the run but sold to Christopher Rourke the present occupant'.

2

THE CLIMATE OF EAST GIPPSLAND

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Abstract

In this analysis of the climate of East Gippsland, the elements of rainfall, hail, snow, temperature and fog are discussed and related to the synoptic features which affect the area.

The most significant feature is the 'east coast depression', which can bring heavy rain to the area and cause flooding. The region has one of the more dependable rainfalls in Victoria, although drought is by no means unknown.

The air temperature can vary from below freezing point in a winter frost, to over 100°F in a summer heat wave. Mean temperatures are not very different from those elsewhere in southern Victoria, but with northerly winds in winter, parts of the region may experience the highest day-time temperatures in the State.

The incidence of fog in the lower river valleys is usually confined to winter mornings, but sea-fog occurs in summer and may affect the coast.

Introduction

The climate of East Gippsland is different in many respects from that of the remainder of Victoria. It is subject to the influence of vigorous depressions off the N.S.W. coast, and incursions of warm, moist subtropical air from the Tasman Sea, and has a climate more akin to that of coastal N.S.W. Rainfall in the area can be very heavy, resulting in rapid flooding of coastal streams. Sea fog is not uncommon in summer, and may affect the coastline, while day-time temperatures in winter may be the highest in Victoria.

Observing Stations

The area has not been well served with climatological stations in the past, although the number has been increased in recent years. At the oldest station, Gabo Island, 100 years of records are available, but since this station is situated on an island off the coast, the records are only typical of the area close to the coast. The station at Orbost has been in existence for over 25 years and those at Cann River and Nowa Nowa for over 15 years, although the records at these latter two are somewhat incomplete.

Stations have been opened in the past five years at Lakes Entrance, Cape Everard and Bendoc, but the period of record is too short for mean values to be calculated. Bendoc, at an elevation of 2,750 ft, is the only station located in the highlands of the area.

There are over fifty rainfall stations, of which twelve have more than fifty years of record. The rainfall stations are situated in the settled parts along roads and river valleys, and thus little is known of the rainfall in the more mountainous country.

Synoptic Features

The predominating circulation pattern which affects Victoria is an irregular succession of depressions and anticyclones. Although these systems generally move

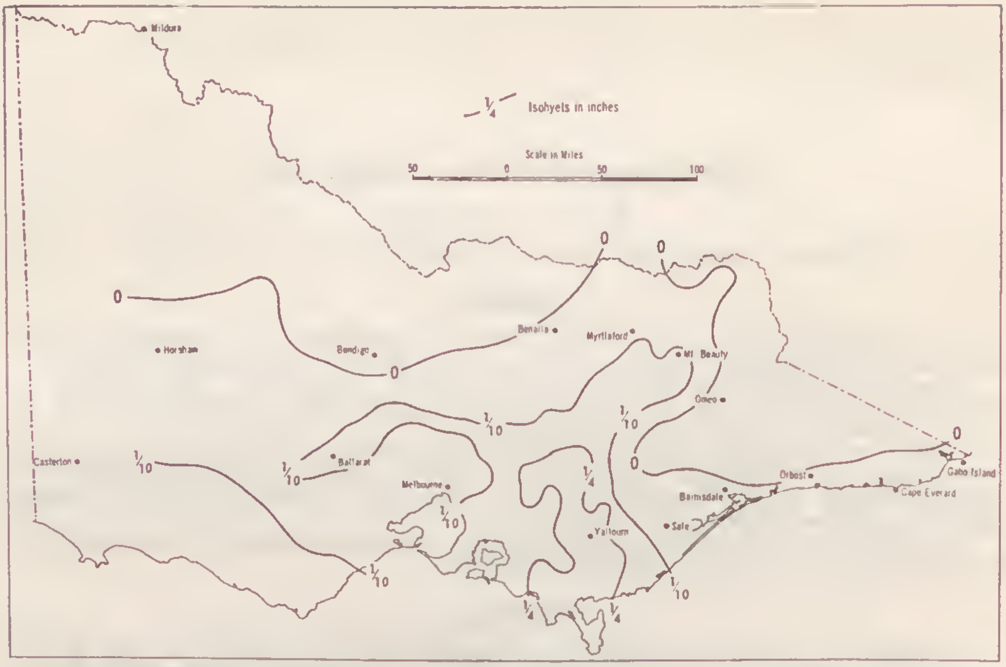

FIG. 1—Rainfall distribution after passage of cold front. Rainfall for 24 hours ended 9 a.m. 11 May 1966.

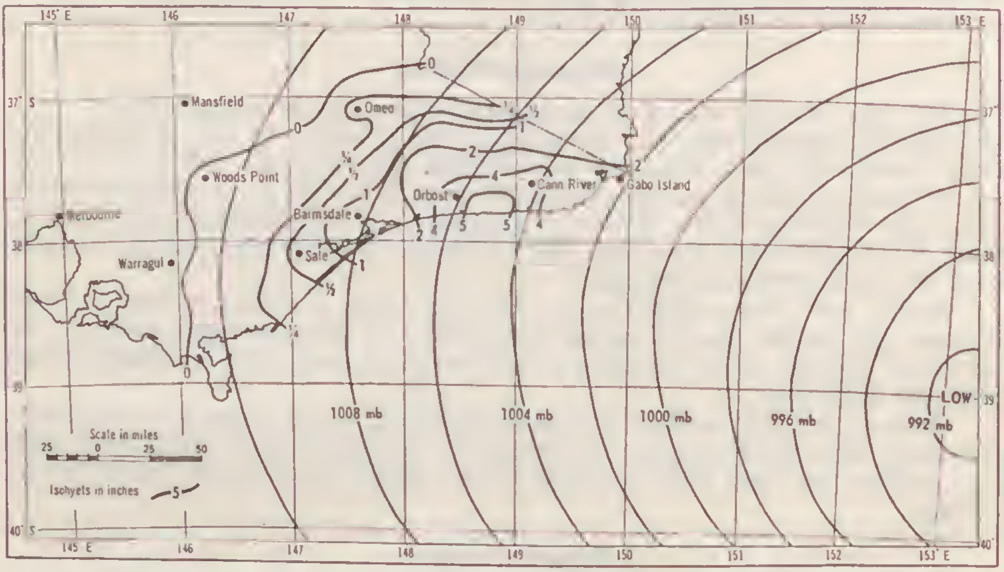

FIG. 2—Surface Isobaric pattern 6 a.m. 21 February 1966 and Rainfall for 48 hours ended 9 a.m. 21 February 1966.

from W. to E., this is not always the case. Systems can develop or degenerate in the area. Their speed of movement can vary considerably, and they can remain quasi-stationary for even a week or more at a time.

A common rain-producing situation for most of southern Victoria is the passage of a depression to the S. of Tasmania, while cold fronts cross Victoria. However, very little rain falls in East Gippsland with this pattern. Fig. 1 shows a typical rainfall distribution.

East Gippsland receives the bulk of its rainfall from depressions centred off the E. coast of Australia. These may have passed through Bass Strait and intensified near Gabo Island, but more commonly, they have developed off the coast of N.S.W. and moved southwards. When the centre is just SE. of Gabo Island, a vigorous southerly airstream is brought to East Gippsland. This air has originated in the Tasman Sea, is warm and moist, and produces very heavy rainfall over most of East Gippsland and particularly between Orbost and Cann River. (See Fig. 2.)

There is no seasonal trend in the occurrence of east coast depressions. Karelsky (1965) has found the number of cyclonic centres in 5° squares of latitude and longitude over the 12 years 1952-1963. (Table 1.)

TABLE 1

NUMBER OF CYCLONIC CENTRES IN 12 YEARS 1952-1963, BETWEEN 35°S AND 40°S

Month	Between Longitudes	
	145°-150°E	150°-155°E
January	9	18
February	2	13
March	3	11
April	7	11
May	12	25
June	11	3
July	10	21
August	8	23
September	14	23
October	10	17
November	7	18
December	8	23
Year	101	206

Not all of these depressions produce heavy rainfall in East Gippsland, as the position of the centre, the intensity, and conditions in the upper atmosphere are all factors determining the amount of rain which falls.

Rainfall

The average annual rainfall over the area is shown in Fig. 3, where the influence of the Snowy River valley can be seen. The driest part of the whole area is found along the valleys of the Snowy and Deddick rivers near the N.S.W. border, where average rainfall is between 25 and 30 inches per year. The mountainous area near Mt. Cobberas, to the W. of these valleys, could be expected to have much higher annual rainfall, probably in excess of 50 inches. The annual average exceeds 40 inches between Cabbage Tree and Cann River and north-

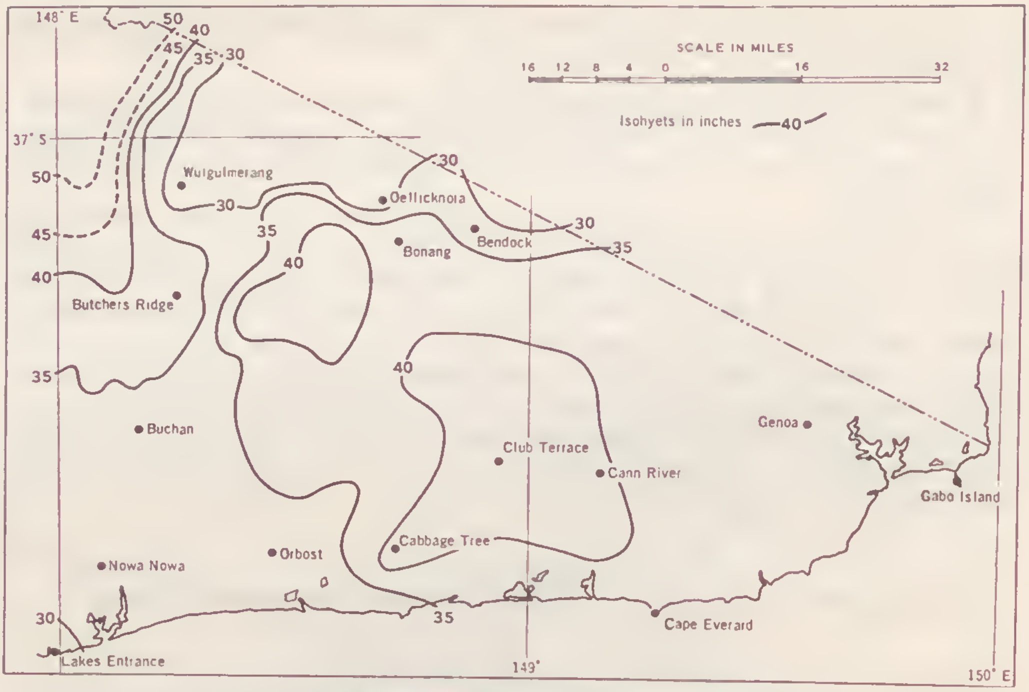

FIG. 3—Average Annual Rainfall—Eastern Gippsland.

wards, and probably also on the higher country between the Brodribb and Snowy rivers.

The variation in the average rainfall through the year is not great, and at the great majority of places, the average rainfall exceeds two inches in each month of the year. There is a slight seasonal maximum in summer in the N. of the area, and a slight winter maximum in the E. This is indicated for two typical locations in Table 2.

TABLE 2
AVERAGE RAINFALL (in inches)

	April-September	October-March
Wulgulmerang	11·41	14·19
Genoa	19·56	17·59

Depending as it does on the incidence of east coast depressions, the actual rainfall can vary considerably from one month to the next. For example, in 1906, Orbost received 0·13″ in February, 10·00″ in March, and 0·92″ in April. The average rainfall is calculated from a small number of high monthly falls and a larger number of low monthly falls.

To illustrate this, the mean and median of monthly rainfall over 53 years in East Gippsland is shown in Table 3. The median is the rainfall which is not exceeded in 50% of occasions. (This district rainfall is the average of the rainfall at the twelve stations: Bairnsdale, Bendoc Park, Bonang, Bruthen, Buchan, Butcher's Ridge, Dargo, Dellicknora, Ensay, Gabo Island, Lakes Entrance and Orbost.

TABLE 3

DISTRICT RAINFALL (inches): EAST GIPPSLAND 1913-65

	Median	Mean
January	1·80	2·47
February	2·05	2·19
March	1·88	2·46
April	2·11	2·46
May	1·92	2·51
June	1·99	2·62
July	1·86	2·40
August	2·05	2·25
September	1·93	2·43
October	2·81	2·94
November	2·36	2·73
December	2·60	2·74

Although some of these places are outside the area under consideration, they form a homogeneous rainfall district). In all months the median is less than the average, and in some by a considerable margin.

However on a seasonal basis, the difference between median and mean is very small except in autumn (Table 4).

The average annual rainfall for the district is 30·20 inches, and the annual rainfall shows less variation from year to year than many other districts of Victoria. The standard deviation of 5·25 inches is 17·4% of the average, compared to a standard deviation of 13·4% of the average in the Western Plains and 28·3% in the northern Mallee.

TABLE 4

DISTRICT RAINFALL (inches): EAST GIPPSLAND 1913-65

	Median	Mean
Summer	7·41	7·39
Autumn	6·80	7·42
Winter	7·25	7·27
Spring	8·02	8·10

At stations with a record of at least fifty years, the annual rainfall has varied from just less than 20 inches to over 50 inches, while 70 inches was recorded in one year at Butcher's Ridge.

Effective Rainfall and Drought

Effective rainfall is defined as the amount of rain necessary to start germination and to maintain plant growth above the wilting point, and has been related to evaporation by Prescott in the formula

$$P = 0{\cdot}54E.^{0{\cdot}7}$$

where P is the effective rainfall and E the evaporation.

Because of the lack of evaporation-recording stations in the area, evaporation has been estimated from the saturation deficit at 9 a.m., and the effective rainfall then calculated.

The chances of receiving rainfall equal to or exceeding the effective amounts for each month of the year have been calculated for a number of places in the area, and expressed as a percentage frequency of occurrence. This frequency ranges from over 60% in summer to over 90% in winter. Thus there is an almost continuous growing season, and in the highlands growth is limited by low winter temperature rather than by lack of moisture.

At Orbost, two consecutive months of non-effective rainfall may be expected in about 50% of years, and three consecutive months of non-effective rainfall in 10% of years. There has been one occasion of four, and one of five, consecutive months of non-effective rainfall. In most cases, these periods occur in the warmer months of the year.

The definition of drought is extremely difficult as the concept cannot be divorced from the use to which water is put. (Gibbs and Maher 1966).

Foley (1957) used rainfall deficiencies to develop an index of drought and to show the severity and duration of past droughts. The following list of the more intense droughts is based on the rainfall at Sale, Bairnsdale, Maffra, Rosedale and Warragul. Although these are outside the area under consideration, three of the stations have a sequence similar to East Gippsland, of dry and wet years.

YEARS	APPROXIMATE DURATION	MONTHS
1882	9 months	Jan.-Sept.
1883-84	10 months	Dec.-Sept.
1885	8 months	May-Dec.
1888	10 months	Apr.-Nov.
1894-95	13 months	Nov.-Nov.
1897-99	19 months	
1908	5 months	Jan.-May
1909-10	11 months	Oct.-Aug.
1911-12	11 months	Aug.-June
1913-16	3 years 2 months	
1922-23	6 months	Nov.-Apr.
1925-26	6 months	Sept.-Feb.
1926-27	10 months	Sept.-June
1932-33	9 months	Sept.-May
1938-39	6 months	Aug.-Jan.
1939-40	11 months	Dec.-Oct.
1943-44	6 months	Oct.-Mar.
1944	6 months	June-Nov.

After a break of twenty years, drought was again experienced in East Gippsland from late in 1964 to the spring of 1965.

As is usually found with the incidence of drought, there is no regularity in its occurrence, and its prediction by statistical means proves impossible.

Rainfall Intensity and Floods

A vigorous east coast depression can cause a large amount of rain to fall in a short space of time. The frequency of 24 hour falls in excess of 3 inches is greater in East Gippsland than in other parts of Victoria. (Table 5).

The most frequent occurrence of this heavy rainfall is in the lower country from Nowa Nowa to Cann River, which receives the full force of a surface depression off the coast. This rainfall frequently causes rapid rises in the short coastal streams such as the Brodribb, the Bemm and the Cann. Heavy rainfall further inland depends on a depression being centred over the land, at least in the upper levels of the atmosphere, and this is a less frequent occurrence. However, the worst floods on

TABLE 5
HIGH 24-HOUR RAINFALLS

Station	Number of 24-hour rainfalls over 3" in 20 years 1947-66	Highest 24-hour rainfall on record (inches)	Month of occurrence of record fall
Bonang	10	4·83	December
Buchan	6	8·45	July
Butchers Ridge	9	9·84	December
Cabbage Tree	16	6·86	January
Club Terrace	11	8·83	October
Delegate River	3	4·50	September
Dellicknora	4	5·00	January
Gabo Island	8	6·64	May
Gelantipy E.	5	4·50	September
Lakes Entrance	7	5·07	May
Nowa Nowa	12	7·78	January
Orbost	7	7·13	December
Brodribb River	9	6·90	March
Sardine Creek	11	4·54	October
Melbourne	3	4·25	January

the Snowy River occur when heavy rain falls over most of the catchment, which extends well into New South Wales.

One of the highest floods on the Snowy occurred in January 1934, when the river reached almost twice the critical height of 17 ft at Orbost and both the bridges at McKillop and Orbost were washed away. Flooding on the Snowy occurs on an average of once or twice a year, and this river can also rise rapidly, e.g. a rise from 3 ft to 23 ft can occur in 24 hours.

Hail and Snow

In southern Victoria, hail is frequently associated with an outbreak of cold southerly air in winter and spring, but it is then usually of small size and does little damage. In summer, the intense convective activity of thunderstorms may produce large and damaging hailstorms.

Because of its local nature, (one hailstorm does not extend for more than a few miles), reliable statistics are difficult to obtain. Orbost has recorded hail on 8 occasions in 10 years, 7 of these being in the winter and spring months. Bendoc in the highlands had recorded hail on 3 occasions in 2 years.

Snow is a rare occurrence over the lower country. It has never been recorded at Orbost, although it has fallen several times at Cann River. Snow falls fairly frequently in winter at elevations over 2000 ft. Bendoc (elevation 2750 ft) has recorded snow 16 times in 2 years, and twice it has fallen as late as October. The mountains, such as the Cobberas (elevation over 6000 ft), would be snow-covered for the winter months.

Temperature

Gabo Island is typical of the equable climate near the coast, the difference between the average maximum and average minimum temperature being only about 10°F in each month of the year. (Table 6). However, even at this island location, century temperatures have been recorded in the summer months, and the temperature has fallen to freezing point in winter.

TABLE 6

AVERAGE AND EXTREME TEMPERATURES (°F)

Station	Altitude (feet)	Data	No. of year of record	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Gabo Island	50	Mean Max. Temp.	50	69·9	70·5	69·6	66·4	62·3	58·5	57·4	58·6	60·7	62·8	65·2	67·7
		Mean Min. Temp.	50	60·1	60·9	59·7	56·2	51·8	48·3	46·5	47·3	49·4	51·9	55·1	57·8
		Highest on record	73	102·5	102·3	101·5	89·0	84·0	83·0	80·0	80·0	85·0	93·0	95·0	101·0
		Lowest on record	73	41·0	43·0	38·0	37·0	33·0	32·0	31·0	32·0	32·0	36·0	34·0	39·0
Orbost	100	Mean Max. Temp.	26	77·3	76·1	74·4	68·5	62·9	58·6	57·9	59·9	63·8	66·8	70·1	74·2
		Mean Min. Temp.	26	54·5	55·3	53·0	48·1	44·1	40·7	39·0	40·1	42·7	46·5	49·7	52·7
		Highest on record	26	108·8	105·1	105·0	94·3	82·9	76·0	71·0	76·7	89·0	93·6	101·8	106·0
		Lowest on record	26	40·0	39·0	38·9	32·0	31·4	28·3	26·4	26·1	27·4	33·1	35·0	38·0
Nowa Nowa	200	Mean Max. Temp.	13	78·9	77·5	76·6	69·4	63·3	58·6	58·1	60·5	64·9	68·2	71·6	75·0
		Mean Min. Temp.	13	52·5	53·8	50·8	46·5	42·3	38·4	35·9	37·4	39·9	44·2	47·9	51·3
		Highest on record	19	109·2	105·8	103·0	91·0	77·0	75·5	69·7	75·0	83·4	91·2	99·6	106·5
		Lowest on record	19	36·5	38·0	36·2	28·1	28·0	23·5	23·4	24·0	25·6	31·0	33·6	38·0
Cann River	250	Mean Max. Temp.	11	78·8	77·1	74·5	69·1	62·0	57·4	56·8	58·9	64·4	67·6	71·4	75·3
		Mean Min. Temp.	11	53·6	54·3	52·3	45·8	41·7	38·4	36·3	37·5	40·8	45·4	48·4	51·9
		Highest on record	16	104·0	107·0	103·2	89·0	76·0	75·2	69·0	74·0	87·0	91·5	98·0	105·0
		Lowest on record	16	37·0	38·0	39·0	31·3	27·4	25·0	26·0	28·0	27·5	31·2	35·5	38·0

The moderating influence of the sea diminishes even only a few miles inland: at Orbost the range between average maximum and minimum temperatures is over 20°F.

The temperature regime is very similar at Nowa Nowa, Orbost and Cann River. All three stations are at elevations of 300 ft and situated 10-20 miles from the sea. The temperature at Orbost exceeds 100°F on one or two days a year on the average, and 90°F on 13 days. (For comparison, the figures for Melbourne are 4 and 19 days respectively).

Light frosts (air temperature less than 36°F) can occur at Orbost during the months April to September, with the average number of occasions per year 30. The temperature rarely falls below 30°F at Orbost, but frequently does so in winter at Nowa Nowa and Cann River.

A feature of the climate of this area is the mild temperatures which can occur on winter days. When northerly winds are blowing over eastern Victoria, particularly if they are bringing rain to the north-east highlands, the dry air descending from the mountains becomes quite warm. This Föhn effect, although not so pronounced as that observed in the European Alps or the Rockies, does cause the temperature to rise to the high sixties or even over seventy degrees. It is not uncommon for this area to have the highest temperatures in the State on these occasions (Fig. 4). Even Gabo Island receives this effect at times, and the temperature has reached 80° there in each of the winter months.

Bendoc, the only station in the highlands, has a period of record too short for precise means to be tabulated. From records over the past four years, the average maximum temperature is in the low seventies in January and the high forties in July. The highest temperature so far recorded is only 92°. The average minimum

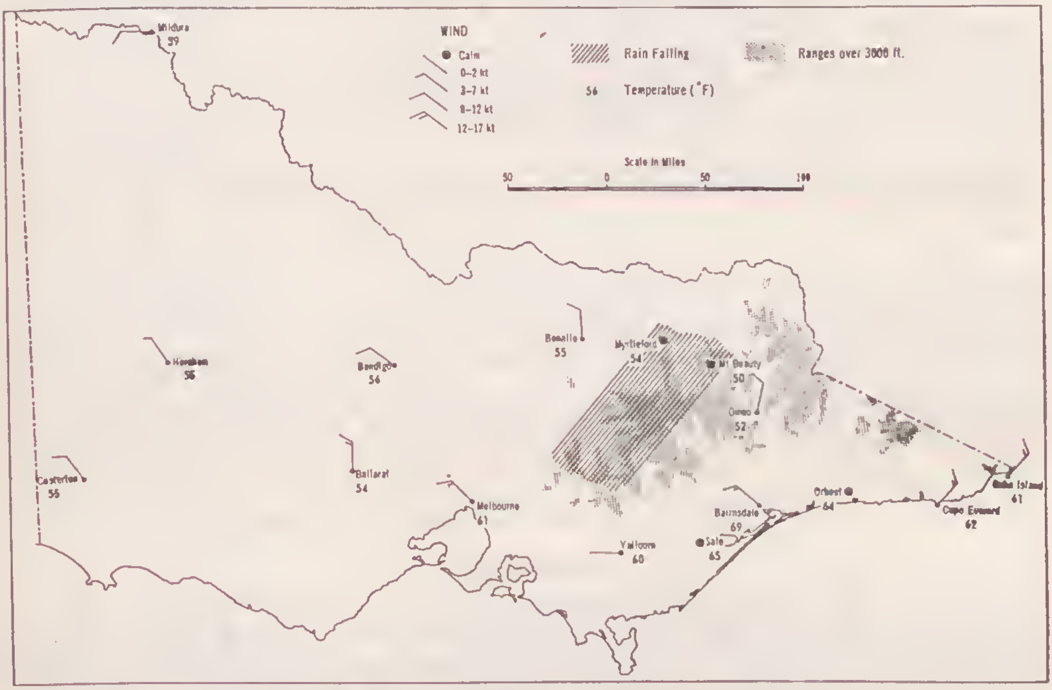

Fig. 4—Föhn Effect in East Gippsland—3 p.m. 1 July 1966.

temperature is in the mid-forties in January and below 30° in July. The lowest temperature so far recorded is 16°. Frosts can occur at almost any time of the year, the period with the temperature remaining over 36° being only 2 to 4 weeks, but it remains over 32° for 3½ to 4 months.

Fog

Fog in most of Victoria is usually due to nocturnal radiation, is more common in the colder months of the year, and occurs at night or in the early morning. However fog along the Victorian coast is usually of an advective nature, e.g. when warm moist air moved over colder water.

This happens in the summer months when a northeasterly airstream brings air from the Tasman Sea over Bass Strait, and sea fog occurs off the East Gippsland coast. The coast itself is not always affected and the average number of days of fog at Gabo Island is only two per year, distributed from October to February (Loewe 1944).

At Orbost the average number of days per year is 10, distributed through all months of the year.

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3

THE GEOLOGY OF EAST GIPPSLAND

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Abstract

Five broadly defined landforms are discriminated in east Gippsland. A mountainous tract is flanked on the N. by extensions of the Monaro Tableland, and on the S. by piedmont downs. These in turn are fringed by a Quaternary dune-swamp complex, and small intermontane basins, largely due to differential erosion, occur within the mountain tract.

Karst features occur in a few areas but the dominant regimen is fluvial. Effects of Pleistocene periglaciation can be discerned on the highest peaks.

The bedrock consists of a complex of tightly folded Ordovician terrigenous sediments, and less strongly folded Silurian terrigenous and carbonate sediments. These are intruded and metamorphosed by a number of latest Silurian or earliest Devonian granitic bodies, of which the largest are the Bega and Kosciusko batholiths.

Early Devonian times witnessed the accumulation of a great thickness of terrestrial sediments, the waxing and waning of acid vulcanism (Timbarra Formation and Snowy River Volcanics), block faulting and planation, followed by a widespread marine incursion and the deposition of the limestone-mudstone complex of the Buchan Group. A period of folding sometime in the Middle Devonian or earliest Upper Devonian (Tabberabberan Orogeny) affected the entire region, and was followed by a further cycle of acid vulcanism (Eden Rhyolites) and essentially continental sedimentation (Merrimbula Group). Further plutonism in late Devonian and late Triassic times is exemplified by the Ellery Granodiorite massif and the syenite-granite porphyry complexes of the Benambra-Mt. Leinster area.

Cainozoic basalts, whose placement reflects generally the mid-Tertiary drainage pattern, occur scattered across the area. Cainozoic sediments are generally restricted to the piedmont-cum-coastal area and are predominantly non-marine, with the notable exception of the Oligocene to Lower Pliocene marine sediments, including limestones, occurring W. of Orbost (Lakes Entrance Formation, Gippsland Limestone, Tambo River Formation and Jemmy's Point Formation).

The incursion reached its maximum in Miocene times. The last events were the deposition of a widespread veneer of sands and gravels in late Pliocene to Pleistocene times (Haunted Hills Gravels) followed in late Pleistocene to Holocene by formation of coastal barriers, lagoons, marshes and alluvial deposits arranged *en echelon* along the coast; these sediments include evidence of a mid-Holocene high sea-level.

The structural evolution of this and immediately adjacent parts of the State is discussed, with particular reference to fault systems and the evidence for wrench faulting not previously noted. The area has been subjected to at least four periods of diastrophism, each of which has produced less intense folding than its predecessor. The Cainozoic was characterized by minor faulting and mild warping.

A brief account is given of the economic geology of the region: minor goldfields in the Bendoc-Bonang, Club Terrace and South Buchan-Mt. Tara areas; small silver-lead mines in the Buchan and Deddick areas; small copper mines at Deddick and Sardine Creek; and iron and manganese shows in the Buchan-Nowa Nowa district. The greatest economic potential appears to lie in the Silurian marbles, the Devonian dolomites and limestones, and the soft Miocene limestones, all of which are present in large bodies.

Introduction

The boundary chosen for the East Gippsland Symposium neatly bisects the region between Buchan, Bindi, Benambra and the Cobberas, where recent investigations have helped to delineate better the Palaeozoic history of the State. The area treated in the present account therefore extends somewhat to the W. of this line, as far as the Tambo R. valley.

The geology and geomorphology of Victoria E. of the Tambo R. was little known until recent years apart from early accounts of reconnaissance by W. B. Clarke (1853), N. Taylor (1866), and by an early government prospecting party led by J. S. Kost (1877). The most prolific early worker was A. W. Howitt (1869-1890) whose activities were confined to the area NW. of a line from Bairnsdale to Bonang. Other prominent contributors were J. Stirling (1884-1899), S. B. Hunter (1897-1898), W. H. Ferguson (1898-1899) and O. A. L. Whitelaw (1898-1921). A useful guide to the scattered literature is given by J. W. Gregory (1907). Since then there have been a number of papers on the Snowy River Volcanics (Samson & Cochrane 1947; Ringwood 1965a, 1965b; Fletcher 1963), and on the following districts: Nowa Nowa (Teale 1920; Bell 1959); Buchan (Talent 1956; Teichert & Talent 1958); Bindi (Gaskin 1943) Mt. Leinster (Broadhurst & Campbell 1933); on Upper Devonian sediments of the Club-Terrace-Combienbar-Buldah area (Spencer-Jones 1967), and on a number of mines in the counties of Tambo and Croajingalong. Relevant studies in adjoining areas are those of P. W. Crohn (1950) for the Omeo district; J. Carne (1897), I. A. Brown (1930, 1931) and L. R. Hall (1959, 1960) for the adjacent part of N.S.W.; E. C. Bird (1965) for coastal morphology of the Gippsland Lakes.

A recent programme of reconnaissance mapping E. of the Snowy R. and more

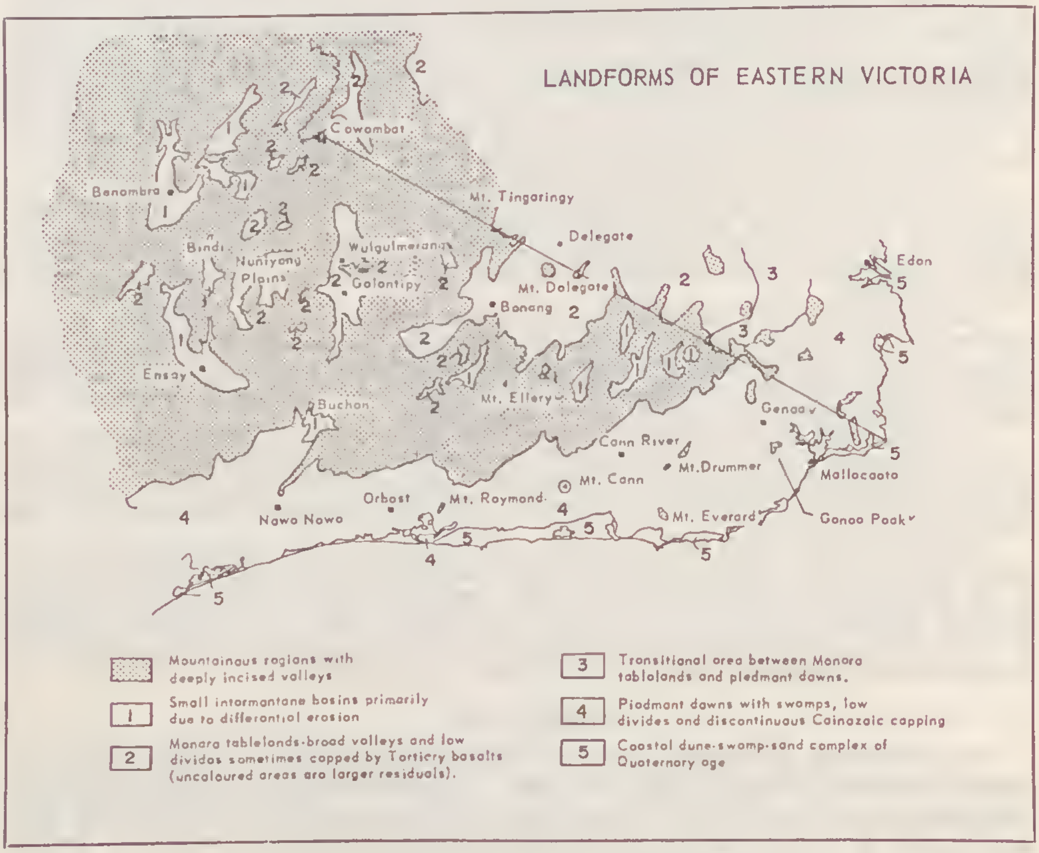

Fig. 1—Landforms of eastern Victoria.

detailed mapping on a scale of 1 mile to the inch of the country between the Tambo and the Snowy rivers has resulted in a clearer understanding of the geology of this part of the State.

Landforms

Five broadly visualized landforms can be discriminated in Victoria E. of the Tambo R.:

1. *Mountainous Tracts*: with deeply incised valleys, concordance of ridge tops often for many miles, and with occasional prominent mountain masses standing above these concordant summit levels as though they represented residuals projecting above a former widespread 'peneplain' or 'peneplains', e.g. The Cobberas, the Bowen Mountains, Mt. Tingiringi, Mt. Ellery and Mt. Elizabeth.

2. *The Monaro Tableland*: extending generally northwards from the mountainous tracts as a gently undulose surface consisting of broad valleys with low divides, scattered mid-Tertiary basalt residuals, and isolated monadnocks, e.g. Mt. Delegate, Wog Wog. A number of rather arbitrarily defined areas of near planar and gently undulose topography bevel the high parts more or less regardless of rock type. These can be construed as outliers of Monaro surface, many likewise including tracts of mid-Tertiary basalts, e.g. the Nunniong-Nunnet tablelands, the Wulgulmerang-Gelantipy-W Tree tablelands, and the gently rolling country N. of The Pilot about the headwaters of the Ingecgoodbee and Moyangul rivers. The Monaro surface falls in a general way SE. from Bombala, merging with the coastal downs in the headwaters of the Towamba and Wallagaraugh rivers.

3. *Piedmont Downs*: a complex of coastal tablelands, subdued ranges, swamps and generally weakly incised streams, though with isolated higher residuals, e.g. Mt. Cann, Mt. Everard, Mt. Raymond, Mt. Imlay and Genoa Peak. Low divides of moderate prominence occur, e.g. the Howe Ranges, the Tableland Hills, and the low ranges about Mt. Drummer. The boundary between the piedmont downs and the mountainous tract is often well defined and has a pronounced *en echelon* trend to the NE. suggesting some possibility of former warping in this direction; this has not been verified to date. There is a discontinuous cover of Cainozoic sands and gravels with probable mid-Tertiary basalts at Club Terrace and South Buchan testifying to the presence of at least some remnants of an earlier Tertiary surface within the complex. Part of the Cainozoic cover is post-Lower Pliocene, since similar beds in extension overlie marine Lower Pliocene sediments about Lakes Entrance. Other parts of the cover are notable for the presence of deep red soils some of which as for example between Cann R. and Cape Everard (E. D. Gill, pers. comm.), appear to have lateritic profiles indicative of a pre-Kalimnan age. In short, within this tract there is evidence for a complex of erosional and depositional surfaces of various Cainozoic ages, stripped and exhumed to varying degrees.

4. *Coastal Dunes*: sands and associated swamp and lacustrine deposits of late Quaternary age distributed *en echelon* along the coast. They include, across the mouths of streams, barriers which are responsible for the development of coastal lakes, particularly Tamboon Inlet, Sydenham and Mallacoota inlets, Lake Tyers, and Wonboyn Lake to the N. The geomorphic history of this region is little known but, like regions further to the W., notably the Gippsland Lakes, it includes the drowning of estuaries and a mid-Holocene high sea-level. This is indicated by dates of 3,780 and 3,560 years B.P. obtained from two superposed samples at Howe Flats, Mallacoota (E. D. Gill, pers. comm.).

5. *Intermontane Basins*: small areas due largely to differential erosion, e.g. Buchan, Bindi (Devonian limestones); Goongerah, Errinundra, Chandlers Creek, Ensay-Swifts Creek (granitic rocks); Cowombat (Silurian mudstones); Combienbar, Buldah (Upper Devonian sediments including mudstones). Earlier workers on adjacent areas of N.S.W. stressed the importance of faulting in the evolution of the landscape, and this opinion is still advocated, though with some reservations, by W. R. Browne (1967) for the highlands extending northwards from the Victorian border. Faulting of the Palaeozoic basement is widespread, but fault control of the landscape and Cainozoic movement along faults is all too often speculative. The dominant land forms are repeatedly explicable as the product of differential erosion, and to this should be added the natural tendency of granitic terrains to weather into linear scarps and depressions.

Minor karst features occur in the areas of Silurian marbles, Devonian limestones and dolomites and Tertiary limestones, more notably in the Limestone Ck-Stony Ck area (Stirling 1884), in the Buchan (Teichert & Talent 1958), Basin Ck, Bindi, Gillingal and Stony Ck (upstream from the Toorloo Arm of Lake Tyers) areas. In all of these the dominant regimen has been fluvial and the karst processes subordinate.

During Pleistocene times the highlands above 4,000 ft, particularly the peaks about the Cobberas, experienced periglacial conditions with developments of rock rivers and the stepping of valleys in association with boulder cascades (Talent 1965a).

Because the Cainozoic history of the area and its geomorphology are intermingled, reference should be made to the Cainozoic section of this paper.

Apart from the restricted plutonism and vulcanism in the Benambra-Mt. Leinster district in late Triassic times, Mesozoic events within the area are not well-known. Hence tectonism associated with this epoch remains speculative. However, the mid-Tertiary basaltic flows furnish a key to some reconstruction of the pre-basaltic relief, giving a measure of subsequent erosion. They provide too, perhaps, a check on the amount of displacement by Cainozoic faulting, now not discriminated over most of the area. At present this would seem the only means of checking the extent of Cainozoic unwarping of the highlands, for which Craft (1933b) arrived at an estimate of no more than 2,000 ft for the Monaro-Kosciusko region.

Stratigraphic Background

The sedimentary and plutonic history of eastern Victoria is complex, with a number of events discernible in different areas. The earliest, affecting the Ordovician basement, are masked by the complex of Silurian and post-Silurian tectonic and plutonic episodes.

No Cambrian rocks have been discovered, though at one stage it was thought that the metamorphic complex of north-eastern Victoria and the Omeo-Ensay district was of Cambrian age (Gregory 1903). With increased regional and detailed mapping, it became apparent that these rocks were in part, if not entirely, metamorphosed Ordovician sediments, originally argillites-cum-arenites. The metamorphic complex has become well known from the pioneer studies of A. W. Howitt (loc. cit.), and studies by C. M. Tattam (1929), P. W. Crohn (1950), and F. C. Beavis (1962), the latter in the Kiewa area. The main metamorphic complex is outside the region under particular attention, but small bodies of similar metamorphic rocks are found E. of the Omeo-Ensay belt: about Mt. Bung, E. of Benambra; about Mt. Misery and in the headwaters of Dead Horse Ck; S. of Davies

Plains; between Mt. Nunniong and Bindi and swinging down on to Junction Ck; as a dividing strip N. of Bentley and Nunnet plains; and as a zone 6 to 10 miles along strike extending S. from the Ellery Granodiorite. W. of Mt. Nunniong the schists and gneisses pass eastwards into lower grade schists and hornfels containing poorly preserved Eastonian graptolites, thus documenting the Upper Ordovician age of these particular metamorphosed sediments. The metamorphic belt extending southwards from the Ellery Granodiorite through Mt. Kuark and Murrungowar reappears as inliers in Cainozoic piedmont deposits, the largest about Mt. Raymond. The belt includes schists, gneisses and granulites as well as granitic bodies, but the most striking rock types are dark, coarse grained non-schistose or poorly schistose metamorphics. The abrupt truncation of this belt by the Ellery Granodiorite suggests tectonic complications of the boundary, or that the metamorphics and their intimately associated granitic bodies antedate intrusion of the Ellery massif. From the relationships between granitic intrusions and metamorphics to the W., one would assume that here too metamorphism took place about the close of Silurian or earliest Devonian times, with some possibility of development during the more indefinite early Silurian diastrophism.

ORDOVICIAN

The Ordovician sediments of eastern Victoria consist of a vast thickness of monotonously uniform, rhythmically deposited geosynclinal sediments, predominantly graded (turbidites), with grain size generally in the range of clay to fine sand. Quartz sandstones are uncommon, though they are more prominent further W. in the Myrtleford-Tabberabbera-Bruthen belt, and within the fault-bounded slices of

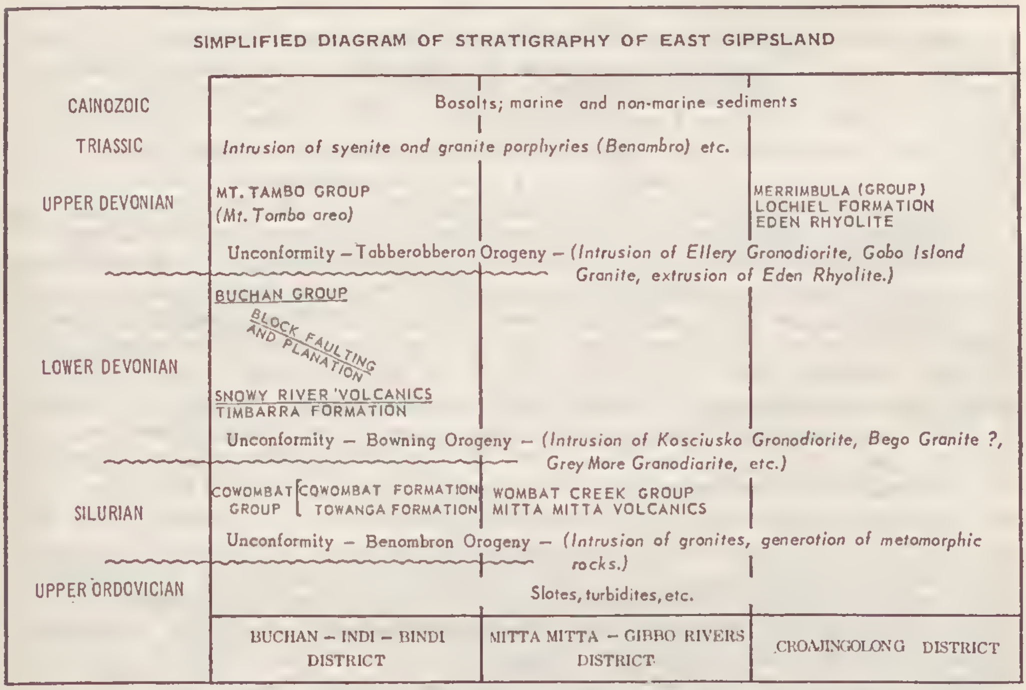

FIG. 2—Correlation chart of the main stratigraphic units of east Gippsland.

east Central Victoria. These quartz sandstones are responsible in the main for the rugged topography of the Bowen Mountains E. from Accommodation Ck, and for the gorge of the Broadbent R. Because of tight folding, the monotony of the sediments, the frequency of faulting and the paucity of fossils, they tend to defy stratigraphic analysis. Slaty cleavage, small scale cross bedding in coarser units, and flute casts are common. Analogues in adjacent N.S.W. are the Adaminaby, Bogong Creek, Bolton and Kiandra beds and their probable equivalents (Moye, Sharp & Stapleton 1963). No tuffs or andesites comparable with those of the Kiandra Beds (Gisbornian) are known.

Upper Ordovician graptolites have long been known from Nowa Nowa, from areas to the N. about Wombat Ck and the Dart and Gibbo rivers, and from E. of the Snowy R. at Cabanandra, Cape Conran, Accommodation Ck (Deddick), Gattamurh Ck and McLaughlin's Ck (cf. Keble & Benson 1939 for refs.). More recently a number of localities have been discovered at Mt. Nunniong, South Buchan, Broadbent R., Barrabilly Ck, and Butcher's Ck. Pre-Darriwilian Da 4 horizons have not been discovered, but wide areas have yet to be examined in detail, so older horizons may well be present. For instance, on the Gibbo R. there is a descending succession to beds containing Da 4 graptolites, which in turn appear to be underlain by a great thickness of unfossiliferous sediments.

SILURIAN

The stratigraphy of the Silurian rocks of eastern Victoria has recently been summarized in this journal (Talent 1965); it will suffice therefore to indicate only the broadest features.

(1) *Sediments and Lavas*

The oldest unit, the Mitta Mitta Volcanics, lies outside the area under discussion in this Symposium; it consists of often highly fragmental ignimbrites (rhyodacites) with subordinate rhyolites, tuffs and minor tuffaceous sediments. It is overlain by the Wombat Creek Group, a sequence of marine conglomerates, limestones and generally fine grained terrigenous sediments at least 10,000 ft in thickness. One minor conglomerate half a mile upstream along the Mitta Mitta R. from its junction with Wombat Ck contains occasional granitic boulders, testifying to the presence of pre-Wombat Creek Group granites somewhere in the vicinity.

In East Gippsland the same sort of succession outcrops in a series of fault slices between Bindi and the headwaters of the Indi R. where it is known as the Cowombat Group. Silurian sandstones, limestones, marbles and fine-grained terrigenous sediments outcrop in this area from beneath the Early Devonian Snowy River Volcanics, with the fault slices tending in the S. to be radially focused on Bindi. In that area are the main developments of conglomerates (the Mount Waterson Formation) which though isolated by faulting, appear to be a lateral development of the basal unit of the Cowombat Group, the Towanga Formation. This is a unit with vast thicknesses of sandstones and some minor conglomerates and limestones, the latter having yielded poorly preserved fossils of Llandovery or Wenlock age. The succeeding units, grouped as the Cowombat Formation and so named because of the paramount importance of the richly fossiliferous development at Cowombat Plain, contains faunas of late Wenlock to early Ludlow age. Metamorphosed segments of the Cowombat Group cross the Ingeegoodbee R. and pass northwards into N.S.W. along the Suggan Buggan Range.

Silurian sediments are known sub-surface beneath the Snowy River Volcanics N. of Nowa Nowa (Talent 1959b), and from between Martin's Ck and the head of

Sardine Ck, but are better known N. of the border at Quidong, Cooma and areas farther to the N. Particularly at Bindi and in the vicinity of Cowombat Plain, relationships show the Silurian succession to have been folded prior to the extrusion of the Snowy River Volcanics. Relationships in general in the headwaters of the Buchan R. show that the Silurian rocks were intruded by the Kosciusko Granodiorite, and that this had been de-roofed before the onset of the terrestrial sedimentary and volcanic events indicated by the Timbarra Formation and the Snowy River Volcanics. The period of intrusion of the Kosciusko Granodiorite is therefore fixed within the time interval of the latest Ludlow and early Lower Devonian (Talent 1959a).

(2) *Latest Silurian or earliest Devonian granitic rocks*

Although the age of the Kosciusko Granodiorite and its ramifications about the Deddick, Timbarra and Buchan rivers can be fixed with some surety, the age of most other granitic bodies to the E. is not so precisely known. The Bega Granite is demonstrably pre-Upper Devonian in age, being overlain by equivalents of the Merrimbula Group. Extensions of it to the N. bearing other names and perhaps not related to it, such as the Boro Granite, are connected with metamorphism and mineralization of Silurian sediments; it would therefore seem to be of generally the same age as the Kosciusko Granodiorite.

It would seem that the Grey Mare Granodiorite has been responsible for the metamorphism of Silurian sediments adjacent to it along the Indi R. Because of extensive faulting, however, and some uncertainty as to how far the Grey Mare Granodiorite extends to the N., no firm decision can be made whether it is latest Silurian-earliest Devonian or younger. The former age range is favoured on regional grounds. Tentatively the granitic masses at Bonang, Delegate River and Irondoon Range, and scattered among the metamorphics N. and S. of Murrungowar are regarded as being also of this age.

The age of the Bete Bolong diorite intrusions and of the Crowstick and Barrabilly diorites in the N. is not definitely known, but is thought to be either latest Silurian to earliest Devonian, or, at the latest, late Middle Devonian to early Upper Devonian.

The fold pattern of the Ordovician basement is to some degree fan-wise, striking approximately NW. to NNW. in the watersheds of the Mitchell, Wentworth and Nicholson rivers, more or less N. in the watersheds of the Gibbo and Buckwong rivers, and with a common trend slightly E. of N. in the watershed of the Snowy R. This fold pattern is therefore disharmonic with the fan-wise arrangement of the Silurian, which trends NW. along the Mitta Mitta R., NE. in the Limestone Creek-Indi River Area (though swinging progressively northwards to the N.), and becoming more easterly eastwards from Bindi. Care is thus necessary in attributing various fracture and shear patterns within the metamorphic belt to a given tectonic episode, using such evidence alone.

DEVONIAN

(1) *Snowy River Volcanics and Timbarra Formation*

Thick sequences of non-marine conglomerates, sandstones, siltstones and minor ignimbrites at least 5,000 ft in thickness constitute the Timbarra Formation, which rests unconformably on the Kosciusko Granodiorite and is overlain by the Snowy River Volcanics. It occurs principally to the W. of Buchan and to the W. of Wulgulmerang (Fletcher 1963; E. R. Woodford, unpub.). Subsequently the Snowy

Limestone Creek, Murendal River. (*A. W. Howitt, 1876*)

River Volcanics complex of more than 10,000 ft of rhyodacites and tuffs with subordinate rhyolites, andesites, keratophyres and basalts accumulated over much of Victoria E. of the Tambo R. The sequence has obviously thinned to a few hundred feet of ignimbrite (rhyodacite) at Errinundra where it occurs interbedded between marine terrigenous sediments below, and limestones correlated with the Buchan Caves Limestone, above. The maximum thickness preserved is in the Wulgulmerang area where the sequence is terminated by tuffs, red beds sometimes with pisolith horizons (Whincup 1947), prominent conglomerates composed mainly of rounded volcanic boulders (Boundary Creek Conglomerate of Ringwood 1955), and with a minor development of trachyandesite (Joplin 1964). A more detailed account of the Snowy River Volcanics succession can be found in the works of Teale (1920), Gaskin (1943), Cochrane & Samson (1947), Ringwood (1955a and b), Fletcher (1965) and Bradley (in press).

(2) *Buchan Group*

Evidence from Bindi, best seen at Mt. Waterson, shows that the Snowy River Volcanics and the underlying Cowombat Group were subjected to epeirogenic block faulting with planation prior to deposition of the Buchan Group, since the lowest unit of this Group rests on the planed surfaces of blocks of Snowy River Volcanics and Cowombat Group sediments (Talent 1965). The same epeirogenic event and planation is apparent in the Buchan area (see discussion under tectonics) and is probably the main reason for the Buchan Caves Limestone resting on different units of the Snowy River Volcanics in different outliers, though the Limestone nowhere rests on the youngest unit of the volcanics, the Wulgulmerang Tuffs. However, the possible lenticularity of the volcanic units must be considered. Yet despite this tectonism, there is remarkable uniformity in lithologic and faunal succession between the various outliers of the Buchan Caves Limestone scattered between Buchan, Bindi, the Indi R. and Errinundra, suggesting original deposition on a near planar surface termed the Buchan-Indi-Combienbar Shelf (Talent 1965). This term was coined to stress this remarkable homogeneity, in the face of recurring statements in the literature that Middle Devonian sedimentation took place in isolated basins. Such an idea originated apparently with a misreading of Howitt, who repeatedly referred to the physiographic expression of these calcareous areas as basin-like, but who recognized them as formerly connected, and deposited 'at a distance from land in seas of moderate depth' (Howitt 1876, p. 209). The preservation of these disconnected bodies is due to a combination of folding and faulting.

For accounts of the stratigraphy and palaeontology of the Buchan Group reference should be made to the publications of Teichert & Talent (1958) and Talent (1965). In the latter publication the Pyramids Member was regarded as being late Emsian or Eifelian and the overlying Murrindal Limestone more probably Eifelian. Later work by Philip (1966) on conodonts would suggest slightly earlier ages with the Murrindal Limestone not extending up to the Eifelian.

Deformation of the Lower to early Middle Devonian sequences of south-eastern Australia took place principally in the interval between the close of the Eifelian and some time early in the Upper Devonian (Tabberabberan Orogeny). This was followed by intrusion of the Ellery Granodiorite which metamorphosed the Lower Devonian to early Middle Devonian succession at Errinundra, and has not affected the overlying Upper Devonian succession. The Gabo Island Granite is referred to the same epoch; it has been shown to intrude the Eden Rhyolite, but is overlain unconformably by arkosic conglomerates and sandstones of the Merrimbula Formation (Hall 1959).

(3) *Upper Devonian*

The Upper Devonian sequence in eastern Victoria is characterized by predominance of terrigenous sedimentation over rhyolitic and basaltic vulcanism. The succession is best known in the Eden district where the Eden Rhyolite, a sequence of over 1,000 ft of rhyolites, ignimbrites and agglomerates differing petrologically from the Snowy River Volcanics, is overlain unconformably by the Lochiel Formation, up to 1,400 ft of basalts with subordinate rhyolites, arkoses, conglomerates, sandstones and red shales. The unit thins to the S. and is lost in the vicinity of Eden, where it is overlapped by the Merrimbula Formation. This latter consists of at least 2,500 ft of arkosic conglomerates, arkoses, sandstones, siltstones and shales; part of the succession at Eden has yielded a meagre marine fauna dominated by *Cyrtospirifer* and *Cyphototerorhynchus*, indicating a Frasnian and probably late Frasnian age. SW. and S. from Eden the Merrimbula Group outcrops as a series of outliers, the main belt extending through Wonboyn and into Victoria at Cape Howe and Mt. Carlyle. Outliers at Mt. Imlay and Timbillica help to establish the former continuity of this succession with the four *en echelon* outliers in Victoria: along the Genoa R. (known as the Genoa River Beds), Buldah, Combienbar and Club Terrace. All these owe their preservation to structural factors (Spencer-Jones 1967).

The Mt. Tambo Group, outcropping in a belt extending from Mt. Bung through Mt. Tambo to Mt. Shanahan near Bindi, consists of 10,000 ft or more of well-bedded reddish to purplish shales and sandstones, with conglomerates up to 40 ft thick. The sandstones and coarser sediments are poorly sorted and commonly cross-bedded reddish to purplish shales and sandstones, with conglomerates up to 40 ft bedded; arkoses are not infrequent, as for example at Mt. Shanahan. The Group is unconformable on the Omeo Schists and Gneisses to the E., faulted against the Snowy River Volcanics and Buchan Group to the SE., and on the W. it has been intruded by The Sisters Granite Porphyry.

TRIASSIC

The landscape about Benambra is dominated by inselbergs and rugged hills of syenite and trachyte together with more subdued hills of granite porphyry. The granite porphyries and syenites with transitional types have been grouped as one igneous cycle (Crohn 1950). Evidence from a number of localities, such as Mt. Little Tambo, suggests that granite porphyries and syenites have intruded the trachytes. The syenites and associated intrusions were formerly regarded as Upper Devonian or early Carboniferous in age, but a K/Ar date has shown them to be of late Triassic age (McDougall 1965).

There is no evidence for igneous or tectonic activity during the remainder of the Mesozoic or early Tertiary.

CAINOZOIC

Cainozoic basalts occur scattered across the area between Bonang, South Buchan and Gibbo River, with the largest masses responsible for the tablelands about Gelantipy-Wulgulmerang and the Nunniong-Nunnet plains. A *Cinnamomum* flora found in association with one outlier on the Deddick road between Little River and McKillop's Bridge is evidence for a mid-Tertiary age for these basalts, though with some qualification because of the persistence of this flora, broadly defined, until later Tertiary (Gill 1952). With the exception of the Morass Creek basalts N. of Benambra, all of these scattered Cainozoic basalts occur as outliers. This indicates that they formerly occupied a much greater area, extending down the Mitta Mitta gorge and for some distance up the valley of Wombat Ck. The Morass Creek basalts lack eruption points: features formerly regarded as such are in fact inliers of Silurian bedrock, and the basalts are remnants of stagnant surfaces being reduced by Morass Ck and the Gibbo and Mitta Mitta rivers. Small outliers of basalt near Club Terrace, from their physiographic situation, are clearly to be regarded as mid-Tertiary in age. Mapping of small outliers of basalt S. and W. of Buchan (Fletcher 1963) has helped demonstrate that the pre-basaltic drainage for much of this area was probably, as now, directed N.-S. Outliers farther N. indicate an ancestral Buchan R. more or less in its present situation, with a large tributary from Nunniong Plains in the W. The same N.-S. alignment is shown by the Wulgulmerang-Gelantipy-W Tree basalts. Basalts at a lower level near the Snowy R. suggest an ancestral Snowy valley more or less in its present situation as far back as mid-Tertiary times.

The Cainozoic succession about Lakes Entrance and to the W. is well known from the works of Carter (1964), Bird (1965), Jenkin (1968) and Hocking & Taylor (1964). The latter refer to the coastal area E. from Lakes Entrance and from it inland up to 6 miles, as the 'Lakes Entrance Platform'. Initial marine Cainozoic transgression over the platform consists of micaceous and sideritic sands with basal gravels passing up into glauconitic sandstone and in turn to dark micaceous, often sandy, marl. This unit, the Lakes Entrance Formation, is of Oligocene and possibly uppermost Eocene age, and is of the order of 150 ft thick in the vicinity of Lake Tyers (Hocking & Taylor 1964). It is overlain by the Gippsland Limestone of Miocene age which forms prominent outcrops in cliffs along the two arms of Lake Tyers at Toorloo and S. of Nowa Nowa, at Hospital Creek (Tildesley R.), and on the W. side of the Snowy R. about Orbost. A decline in carbonate sedimentation and an influx of terrigenous sediments is found in the succeeding latest Miocene beds known as the Tambo River Formation, representing an early phase of marine regression. This unit is known as far E. as Lake Tyers but has not yet been found further E. Marine sedimentation continued to contract towards the Lakes Entrance district with a last marine Tertiary unit, the Jemmy's Point Formation, consisting of calcareous sands and silts passing upwards into lagoonal sediments of the Myerimalang Formation (Wilkins 1963). These in turn doubtless grade landwards into the later Pliocene-to-Pleistocene Haunted Hills Gravels which, loosely defined, extend as a veneer northwards to Buchan, eastwards to Mallacoota, and into N.S.W. about Timbillica and Cape Howe. Evidence from the elevation of marine shell beds at various localities in the Gippsland Limestone shows that these sediments have been mildly upwarped landwards to as much as 180 feet near the Colquhoun granite quarry (Wilkins 1963). The same upwarping is reflected in the way each of the Tertiary formations dips seawards [allowance being made for initial dip].

The Pleistocene and Holocene history of the area E. of Lakes Entrance is not well known, but the work of Jenkin (1968) and his predecessors provides a detailed account of areas to the W.; this would be the basis from which the coastal history to the E. would be judged. No attempt is here made to establish a sequence of events in the development of coastal barriers, lagoons, marshes and alluvial deposits in this area; these deposits are arranged in *en echelon* fashion, the more notable developments occurring about the mouths of the Snowy, Bemm, Cann, Thurra and Genoa rivers. A mid-Holocene high sea-level recognized at many localities farther W. is exemplified by dates of 3780 and 3560 years B.P. obtained for two superposed shell beds at Howe Flats E. of Mallacoota (E. D. Gill, pers. comm.).

Attention is drawn to the deep kaolinization of the granitic rocks of the area, readily appreciated in cuttings on the Princes' Highway, and to possibly lateritic profiles developed on Cainozoic sediments such as those along the Cann River-Cape Everard road. E. D. Gill (pers. comm.) has pointed out the significance of these for possible discrimination of his (Gill 1964) mid-Tertiary Nunawading and Lower Pliocene Timboon terrains.

Structure

A region of anastomosing lanceolate and deltoid fault blocks occupies an area centred on Buchan. A series of major faults fans out from Nowa Nowa towards Bindi in the NW. and Bonang in the NE. The same arcing pattern is interrupted by Triassic granitic and syenitic intrusions about Benambra, but extends beyond this, passing to the N. and NW. into a region of generally less spectacular rhomboidal fault blocks indicative of a generally more homogeneous stress pattern. To the NE. the pattern of lanceolate fault blocks becomes more attenuate as it passes northwards towards Tumut and Canberra. The structural pattern is less clearly known E. of the Bonang Highway for in this area there is a general lack of the wide variety of Silurian and Devonian sedimentary and volcanic units that have enabled deciphering of the broader tectonic history of the area to the W.

A. The Snowy River Volcanics Belt and Areas to the North

The tectonic history of eastern Victoria can be deciphered in more detail in the areas in, and adjacent to, the Snowy River Volcanics belt, the Mitta Mitta Volcanics belt, and the area about Benambra, for in this area the multiplicity of stratigraphic units and igneous bodies enables the sequence of tectonic, stratigraphic, volcanic, plutonic and palaeogeographic events to be sorted out.

Broadly speaking, Bindi is the focal point for convergence of a number of arcing fault systems. The Indi Fault from the NE. swings southwards as it crosses the Tambo River N. of Bindi, and then swings progressively towards the SE., heading approximately in the direction of Buchan. It is poorly known S. of the Junction Creek-Little River Divide, though reconnaissance mapping seems to indicate that the intensity of movement was dissipated in a series of parallel faults. But along the same trend about 12 miles to the SE., near Mt.Gilgroggin at the junction of the Timbarra R. and Wilkinson Ck, the mapping of Fletcher (1963) has documented a fault boundary between the early Devonian Timbarra Formation and Ordovician sediments on the W. The same fault boundary then swings slightly W. of S. in the general direction of Lakes Entrance until lost beneath the Cainozoic cover of the coastal downs.

Net movements along the Indi Fault during the Tabberabberan deformation resulted in downthrow to the E. and preservation of the vast thickness of the Silurian Cowombat Group, early Devonian Timbarra Formation, early Devonian Snowy River Volcanics, and late Lower Devonian Buchan Group. All these units were completely removed from adjacent parts of the upthrown block to the W. prior to deposition of more than 10,000 ft of Mt. Tambo Group sediments. That all these units were removed and that the Upper Devonian sediments on the westerly block now rest directly and unconformably on metamorphics and Ordovician sediments is an impressive measure of the displacement along this fault and the erosion that occurred during roughly Middle Devonian times. Preservation of the Mt. Tambo Group, on the other hand, is sound evidence for a reversal of movement on the fault at some time since the Devonian. Part at least of a westerly block was downthrown and the Mt. Tambo Beds stripped from the easterly block. Needless to say, there must have been formerly some Mt. Tambo Beds on the easterly block, for they are truncated by the Indi Fault. Nevertheless, the overall displacement in relation to Tabberabberan and later, presumably Kanimblan (Lower Carboniferous) movements, was one of downthrow to the E.

Evidence is lacking for the existence of the Indi Fault prior to deposition of the Buchan Group in late Lower Devonian times, but the harmony of its trend with

Junction Buchan and Murendal Rivers. (*A. W. Howitt, 1876*) that of a system of faults sweeping south-westerly from the upper Buchan R. towards Bindi is apparent. This fault complex includes the Hell's Hole, Carrabungla and Reedy River Faults (Talent 1967) and, though the pattern of faulting E. of Bindi is known in broad fashion only, the system as a whole sweeps in towards Bindi, jumbling blocks of Cowombat Group (Silurian), Snowy River Volcanics (early Devonian) and, further out, blocks of schisted Ordovician sediments and granitic rocks of presumed early Devonian (pre-Snowy River Volcanics) age. And yet the lowest unit of the Buchan Group was deposited indiscriminately over the planed surfaces of these blocks (Talent 1965), testifying to post-Snowy River Volcanics, pre-Buchan Group block faulting and planation. It seems reasonable to assume that the parallel Indi and Bindi faults to the N. and S. were in existence at that time and that it was these latter only of the system which were involved in subsequent displacements. As far as stratigraphic evidence is concerned, there would be no grounds for inferring pre-Middle Devonian movements along the Bindi Fault, but its intimate associaton with the whole system of the Indi, Hell's Hole, Carrabungla and Reedy River Faults leads one to assume pre-Buchan Group movements as well as movements in the Tabberabberan and Kanimblan diastrophic epochs. The post-Palaeozoic igneous activity of the Benambra district, now dated as late Triassic (McDougall 1965), is associated with relatively minor tectonic disruption. There is a general concordance of trachytes associated with the syenites scattered over an area of about 100 square miles, the coarser plutonic rocks of this association as it were exhumed, though retaining remnants of trachyte 'skin'. Though the example is small and the tectonic pattern obscured by alluviated valleys and poor outcrops between the igneous masses, one is led to the tenuous conclusion that this area has not been dislocated on anything like the scale involved, for instance, in the downthrow and preservation of the Mt. Tambo Beds along the Indi fault. A still more tenuous conclusion is that large scale fault movements had ceased in this area by late Triassic times.

N. of Benambra the Mitta Mitta Volcanics and Wombat Creek Group outcrop within an attenuate fault-bounded strip, structurally a graben but no longer presenting this physiographic form. The bounding Wombat Creek and Morass Creek Faults converge towards the foothills of The Brothers NE. of Benambra, where their presence is doubtless indicated by Silurian sediments about Pyle's Deposit. These large scale faults have not been detected further S. in the Mt. Tambo-Sisters region of Upper Devonian sediments and Triassic igneous rocks. These would appear to conceal the extension of these faults and thus to set an Upper Devonian upper limit for appreciable movements along them. On the other hand, their trends line up well with the southward to south-easterly swing of the Indi Fault about Bindi and accordingly they could be assumed to have been confluent. Once again, the evidence indicates more profound faulting before the Upper Devonian than during or after Upper Devonian times.

A number of moderate to large scale faults have been detected bounding or within the Snowy River Volcanics belt in the general vicinity of Buchan and Gelantipy, strewn across the area between the Timbarra and Yalmy rivers. The major pattern is a N. to NE. directed fan, the most westerly already discussed as a probable extension of the Indi Fault, and the most easterly the Yalmy Fault, along which the Devonian sequence has been downthrown against an easterly block of Ordovician sediments on which Silurian or Devonian units are lacking for some miles. The Yalmy Fault and its prominent crush zone would therefore appear to be one of the major structural features of eastern Victoria.

Mapping of the Ordovician enclaves within the Snowy River Volcanics belt

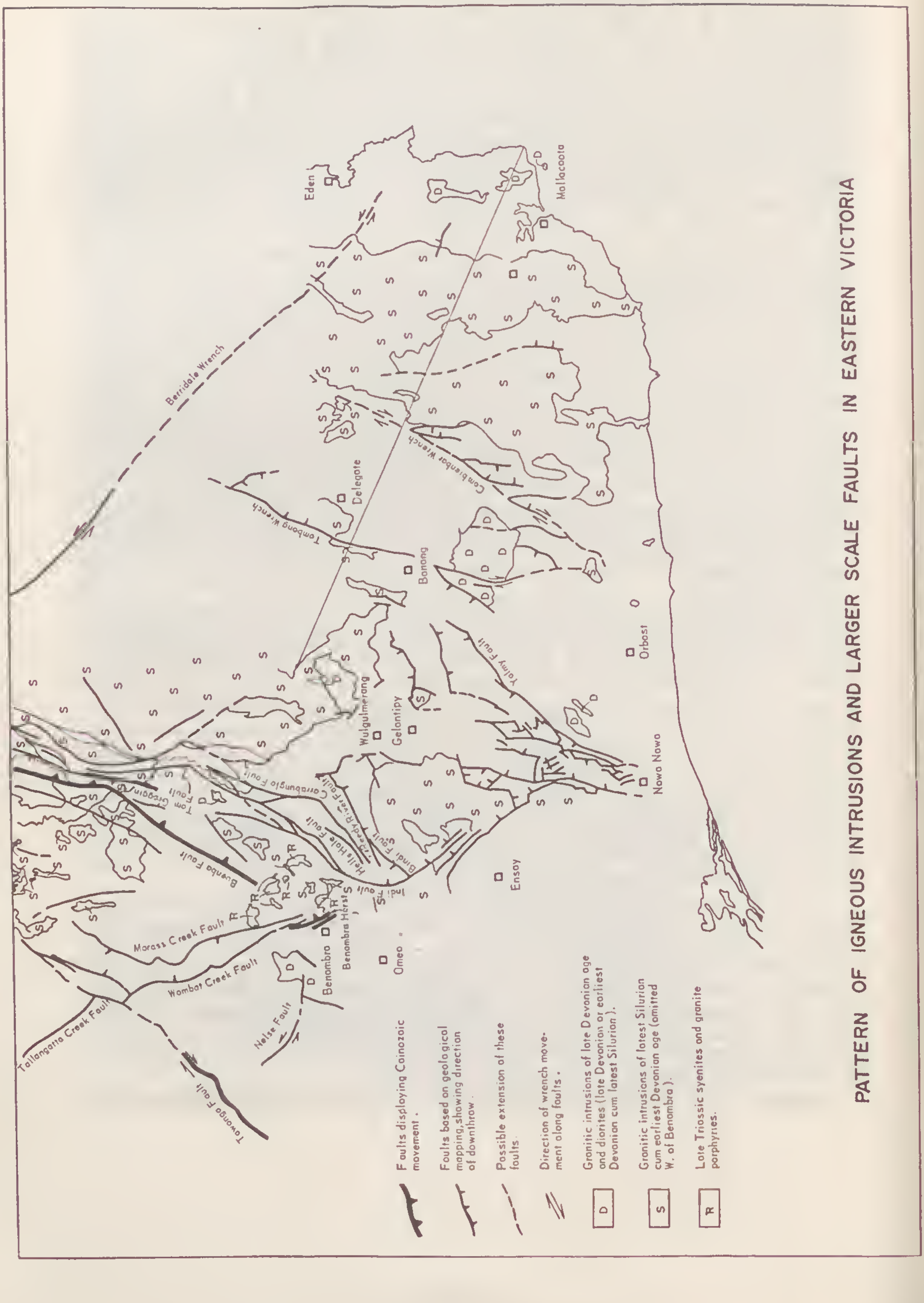

Fig. 3—Pattern of igneous intrusions and larger scale faults in eastern Victoria.

about Nowa Nowa (most recently by Bell 1959) and the discovery by drilling of Silurian sediments beneath the intervening strips of Snowy River Volcanics (Talent 1959) reveal the enormity of fault displacements in this area. Further N. along the strike of these faults there is an obvious contrast between the deformation and scale of faulting within the Buchan Group, which there lies as a drape over the jigsaw of fault blocks. This contrast has been adduced as evidence for block faulting and planation of the Snowy River Volcanics prior to deposition of the Buchan Group, an event more readily discernible at Bindi (Talent 1965). Northwards from East Buchan, fault blocks of Ordovician sediments and granitic rocks about Mt. McLeod and on the New Guinea Road near Butcher's Creek show the continuing importance of displacements by faulting within the Snowy River Volcanics belt (Bradley, in prep.). Two easterly directed tongues of Snowy River Volcanics extend across the Snowy River towards Bonang, the more northerly including the Bowen Mountains about Deddick, and the southerly occupying much of the watershed of the Roger R. Though the northerly margin of the Mt. Deddick tongue appears to be in essence a normal unconformable contact with Ordovician sediments and earliest Devonian or latest Silurian granitic rocks, the intervening tongue of Ordovician sediments and granitic rocks in the valley of the Snowy R. about Campbell's Nob and eastwards up the watershed of the Broadbent R. is largely controlled by faulting. This is particularly apparent near the mouth of the Broadbent R. where thin slices of Ordovician sediments are interleaved with slices of Snowy River Volcanics. The main E.-W. boundaries of the Volcanics N. and S. of the Broadbent River are faults; these E.-W. structural trends are repeated N. of Gillingal and N. of Timbarra where N.-S.-striking belts of Snowy River Volcanics and an attenuate strip of Buchan Caves Limestone are cut off at right angles by E.-W. faults (Fig. 3). The occurrences of limestones within the Snowy River Volcanics belt at Gillingal, Jackson's Crossing, Butcher's Creek and at the Murrindal or Hume Park lead mine are all associated with faults.

B. East of the Snowy River Volcanics Belt

For pre-Upper Devonian plutonism and tectonism E. of the Bonang Highway and E. of the Snowy R. in adjacent N.S.W., evidence is scattered. At Errinundra (Thomas 1947) a sequence of tuffaceous sediments and ignimbrites overlain by limestones contains fossils that, despite poor preservation, strengthen the analogy with the Snowy River Volcanics and Buchan Group farther W. These Lower Devonian units were folded into a syncline and down-faulted prior to deposition of Upper Devonian sediments of the Club Terrace-Bemm River outlier. The relationships of the Silurian marbles and conglomerates between Martin's Ck and the head of Sardine Ck to the Ordovician bedrock of eastern Victoria is not known, but at Quidong, between Delegate and Bombala, a gently folded Silurian succession is faulted against, but also demonstrably unconformable over, tightly folded Ordovician sediments. Other scattered occurrences of Silurian sediments to as far E. as Bendethera near Moruya indicate the former widespread and presumably continuous Silurian seas over the entire area, and presumably everywhere essentially unconformable with the previously folded Ordovician succession. The preservation of these scraps of Silurian and Lower Devonian seems to be everywhere connected, at least in part, with major faulting.

Small tectonic basins preserving Upper Devonian sediments at Combienbar, Buldah and Club Terrace bear witness to the existence of a number of strong N.-S. post-Devonian faults (Spencer-Jones 1967). These faults and the attitudes of the basins indicate the presence of a major wrench fault, the Combienbar Wrench, in which the north-westerly block has moved upwards and to the NE. relative to the south-easterly block in which the Upper Devonian sediments have been nipped in and preserved. The Berridale Wrench extending from Disaster Bay north-westerly through Berridale towards Kiandra (Lambert & White 1965) seems to be conjugate with the Combienbar Wrench.

A further wrench with lateral translation of 3 to 4 miles, here termed the Tombong Wrench, is postulated as sweeping up northwards from this vicinity of Mt. Jack through Goongerah; it would thus account for the apparent northerly migration of a western sliver of the Ellery Granodiorite. Extension of this line to the NNE. into N.S.W. would pass through Tombong and close to the W. side of the Quidong Silurian outlier where there is known structural complexity, and serpentinites and other sheared rocks are present (Relph & Wynn 1960). The trough at Quidong contains Silurian sandstones passing up into shales and limestones, and another between Tombong and Delegate contains Silurian or Devonian sandstones; these can be regarded as large scale synforms produced in part as a result of lateral translation along this line, the more westerly block riding northwards (dextrally) relative to the more easterly block. A small body of granite between Mt. Koolabra and Bendoc may be a fragment torn from the Delegate River intrusion by the wrench. The southerly extension of the wrench could well sweep down and form part of the western margin of the Mt. Kuark-Murrungowar metamorphic belt. The mapped outline of the Ellery Granodiorite suggests a fault, downthrown to the E., passing through the pluton and forming the eastern boundary of the Mt. Kuark-Murrungowar metamorphic belt.

Dislocation of the Ellery Granodiorite would be evidence for post-Upper Devonian movement along the Tombong Wrench, but the magnitude of possible older movements cannot be determined from the stratigraphic units located along its presently known extent. The Tombong Wrench, viewed simply, could well extend beneath the Monaro basalts to join with the Murrumbidgee Fault system and so to Canberra (cf. Canberra 4 mile Sheet, Bureau of Mineral Resources). Likewise the Combienbar Wrench, if projected N., could join in some way with the Shoalhaven Fault system.

The bedrock E. of the Bemm and Combienbar rivers is largely made up of two N.-S. tongues of granodiorite divided by a narrow belt of Ordovician terrigenous sediments averaging 6 to 10 miles in width. The granitic tongues join near the border SE. of Nungatta, though the belt is echoed further N. by a thin screen of Ordovician sediments W. of Towamba. The western margin of the Ordovician belt is faulted E. of Mt. Drummer on the Princes' Highway. The general northerly trend of this fault sweeping up the boundary between the Bega Batholith and the Ordovician sediments is the same as those bounding the Upper Devonian outliers farther west. It may have originated earlier, but can be reasonably assumed to have, like them, experienced appreciable movement during the post-Devonian (?Kanimblan) era of wrenching.

The Upper Devonian sediments N. of the border in large measure owe their preservation to faulting. The eastern bounding fault of the Platts-Maharatta enclave extends towards the Victorian border as the western boundary of the Bega Batholith. The Upper Devonian outlier at Mt. Timbillica appears to be truncated by faulting to the N. and S. Even allowing for unconformities between the Eden Rhyolite, the Lochiel Formation and the Merrimbula Group about Eden, the pattern of mapped outcrops (Hall 1959) seems to indicate that the problem there too, may be complicated by block faulting, e.g. NE. of Towamba in the vicinity of the Sugarloaf goldfield.

The overall pattern of the various Devonian enclaves E. of the Bonang Highway thus emphasizes the magnitude of the post-Devonian tectonic movements in their vicinity. It seems reasonable to assume that intervening areas now lacking such distinctive markers have not escaped comparable tectonism.

C. CAINOZOIC MOVEMENTS

Evidence of Cainozoic tectonic movements in the area is far from widespread. None of the Cainozoic basalts of the Wulgulmerang-Gelantipy-W Tree, Bonang, Nunniong-Nunnet or Morass Creek areas show obvious disruption by faulting. Basalts within the valley of the Snowy River E. from, and at a lower level than, those at Wulgulmerang may be construed on casual appraisal to owe their reduced elevation to later Cainozoic faulting, but evidence for this is otherwise absent. These mid-Tertiary, approximately Oligocene, remnants seem rather to be related to an older, less incised valley of the Snowy R., and are perhaps of more interest as a yardstick for appreciating the rate of excavation of the gorges of the Snowy R. through resistant Snowy River Volcanics to the S.

On the present evidence the cause of the abrupt seaward swing of the marine Tertiary boundary in the Orbost-Marlo area could be explained either by warping, or by irregularity of the shore line in Miocene times. The history of Cainozoic warping, particularly in Plio-Pleistocene times, westwards from Lakes Entrance and in a general way parallel to the margins of the Gippsland Basin is given by Jenkin (1968). While the importance of structure within the Gippsland Basin has become well known, it could be said that theories of warping of the highlands with consequent influx of terrigenous sediments have been over-emphasized at the expense of climatic change, particularly with regard to the widespread, predominantly Plio-Pleistocene 'torrent gravels'. The deposition of the 'gravels' is so extensive and relatively abrupt that it is difficult to visualize it as resulting from block faulting and doming and rejuvenation of streams. The focus of maximum uplift was over 100 miles N. of the present 'torrent gravels' sheet, and the elevation involved in that area was no more than about 2,000 ft since approximately Oligocene times, the pre-basalt relief of the Monaro-Kosciusko region being no more than 3,500 to 4,500 ft according to Craft (1933b). Rather, the 'torrent gravels' give the impression of having been distributed across the piedmont areas by streams wandering about like so many loose hoses with greatly augmented flow—the products of a pluvial cycle or cycles.

Some fault movements in Cainozoic times can nevertheless be documented: the Tawonga Fault over-riding river gravels (Beavis 1960); the small horst at Benambra damming Lake Omeo; the Buenbar Fault responsible for gorges on the Gibbo R., the Murray Gates gorge at Tom Groggin, the Devil's Grip gorge on the Swampy Plains R., and the extensive alluvial flats upstream from the fault at Beloka, Buenbar, Tom Groggin and Geehi. However, such Cainozoic movements have yet to be documented in the highlands E. of the Tambo R. The Tara Range may owe its prominence to Cainozoic faulting; the abrupt seaward swing of the marine Tertiary margin about Orbost may be the expression of a warp. These questions remain open.

Sequence of Tectonic Events

1. Tight folding of the Ordovician terrigenous sediments along axes trending between NW. and slightly E. of N. in early Silurian times.
2. Intrusion of granitic rocks in early Silurian times, and presumed generation of the Omeo Schists and Gneisses.

3. Extrusion of the Mitta Mitta Volcanics.

4. Deposition of the essentially terrigenous Cowombat and Wombat Creek Groups and their equivalents, the Quidong Group of N.S.W., with shoreline somewhere to the N. and NW. of Bindi.

5. Period of folding (Bowning Orogeny) producing a more widely spaced fold pattern than that produced during the early Silurian diastrophism; this pattern is fan-wise and disharmonic with that produced previously in the Ordovician sediments.

6. Intrusion of the Kosciusko Batholith and, almost certainly, of the Grey Mare, Bega, Irondoon, Murrungowar, Delegate and Marengo acid intrusives; presumed period of formation of the Mt. Kuark-Murrungowar metamorphic belt.

7. Deposition of the Timbarra Formation and accumulation of the Snowy River Volcanics following de-roofing of at least the Kosciusko Batholith.

8. Earliest discernible movement on the Indi, Bindi, Hell's Hole, Carrabungla and Reedy River Faults, the East Buchan Fault System, and presumably the Yalmy Fault.

9. Planation, followed by deposition of the Buchan Group after subsidence of the Buchan-Indi-Combienbar Shelf.

10. Period of folding (Tabberabberan Orogeny) producing broad regional folds in the Snowy River Volcanics with minor tighter folding in the less competent units of the Buchan Group. This event occurred post-Eifelian, pre-sometime in the early Upper Devonian. Movements along some major faults, best known for the Indi Fault. Certain older faults, e.g. Carrabungla and Hell's Hole Faults, suffered no displacement in this or later diastrophic events.

11. Post-orogenic plutonism typified by the Ellery Granodiorite and the Gabo Island Granite; this event was in part contemporaneous with those of 12, the Gabo Island Granite being presumably consanguinous with the Eden Rhyolite.

12. Widespread terrigenous sedimentation (Merrimbula and Mt. Tambo Groups) following the acid and basic vulcanism in the E. (Eden Rhyolite, Lochiel Formation), though perhaps not extending into Victoria.

13. Diastrophism resulting in appreciable movements along the Combienbar and Tombong Wrenches, presumably responsible in a general way for the generation of the synclinal bodies of Upper Devonian sediments about Combienbar, Buldah, Club Terrace and Genoa River. Tilting of the Mt. Tambo Beds and renewed movements, presumably soon afterwards, along the Indi Fault, causing reversal of previous movements with downthrow to the W.

14. Intrusion of the granite porphyry-syenite complex of the Benambra-Beloka-Marengo area in late Triassic times.

15. No record of events from Jurassic to Lower Tertiary times.

16 a. Downwarping and marine incursion over the Lakes Entrance Platform commencing in Oligocene or latest Eocene times and reaching its maximum extent in Miocene times.

b. Extrusion of Tertiary (?Oligocene) basalts down valleys oriented broadly the same way as present drainage..

17 a. Regression of the Tertiary seas in latest Miocene and Lower Pliocene times, doubtless fringed by non-marine terrigenous sediments, these advancing with retreat of the sea to form the Haunted Hills Gravels.

b. Movements along the Buenbar and Tom Groggin Faults; uplift of the Benambra Horst, damming Lake Omeo; minor upwarping near the coast.

18 a. Periglaciation of the highest peaks at some time or times during the Pleistocene.

b. Formation of the lunette-alluvial-swamp-sedimentary complex about Lake Omeo and Morass Creek.

c. Formation of older river terraces and alluvial fans e.g. along the Tambo R. about Swift's Creek.

d. Formation of the inner barrier of the Gippsland Lakes, and undefined shoreline accumulations further E.

19. Formation of the Holocene dune-swamp-sand-alluvial complex along the coastal fringe; associated with this is evidence of a mid-Holocene high sea level.

Economic Geology

There has been no major exploitation of metals in eastern Victoria. Small to moderate quantities of gold, silver, lead, molybdenum, iron and manganese have been mined, though presently known resources are insufficient for economic output, even with improved transport and access to the most remote prospects. There is greater potential in the industrial minerals, particularly the limestones, dolomites, building marbles and perhaps barite.

Gold has been mined from reefs and alluvial deposits scattered primarily across outcrops of Ordovician rocks eastwards from Buchan. Promising but small alluvial deposits are known from the Timbarra River, but no mines have been developed in that area. Generally small, but often surprisingly rich, mines have been worked in the Tara Goldfield S. of Buchan; all of these were located in Ordovician rocks except for the Monarch and the Tara Crown (or Armistice) mines—these were in Snowy River Volcanics (Teichert & Talent 1958). Perhaps the area most intensively prospected for gold is the Bendoc-Clarkeville-Bonang-Delegate River area. In the Bendoc-Clarkeville district a number of quartz reefs were worked to depths of 300 ft. The deepest shaft in the area is on the Rising Sun Reef at Bonang; it was sunk to 500 ft and the reef stoped out to the surface (Dunn 1909). Alluvial gold from these reefs and quartz stringers has been worked in alluvial flats along the Bonang, Delegate, Little and Bendoc rivers. A number of quartz reefs have been worked about Club Terrace, e.g. on Millionaire Gully (Kenny 1937a); the reefs repeat for three miles but, though surface prospects were often excellent, the quality did not persist in depth (Murray 1898; Stirling 1898). Farther E. there are minor gold occurrences, at Mallacoota for example, but these have no significance compared with the Yambulla Goldfield just N. of the border.

High *platinum-osmiridium* values have been obtained at the Bounder Mine, Errinundra (Kenny 1937).

Silver-lead mines and prospects are principally located about Buchan in the basal dolomites of the Buchan Caves Limestone (Teichert & Talent 1958), and at Deddick in granodiorite (Ferguson 1899). Ore with a high silver content has been mined at the Glen Shiel Silver Mine, Gelantipy East (Dunn 1907; Whitelaw 1921). There are a number of small lead shows scattered about the Buchan district from Ferntree Creek to Canni Creek and New Guinea Point on the Snowy R. A small quantity of silver-lead ore has been won from the silver mine at Boulder Flat S. of Errinundra. A few small lead-zinc bodies with ferruginous gossans occur in the Limestone Ck district and, though one of these assayed up to 36·6% zinc, none has proved economic (Mahoney 1936).

Small bodies of *molybdenum* ore occur at Wangrabelle where shafts have been sunk to a depth of 70 ft (Herman 1920); molybdenite has also been mined just N. of the border at Wog Mountain (Hall 1959).

Small quantities of *barite* have been mined at the Glen Shiel Mine, Gelantipy East, and on the Old Basin Road, East Buchan. It is known from a number of localities southwards from South Buchan, and at the Errinundra silver mine, Boulder Flat, Errinundra.

Graphite occurs in small quantities on Sundown Ck about 3 miles NW. of the Princes Highway at Bell Bird Creek (Herman 1920).

There has been no quarrying for *feldspar* in the area, though largish masses of soda-feldspar adjoining a gneiss-granite contact at Mt. Raymond E. of Orbost have attracted interest. Pegmatite dykes within the area are worthy of investigation, because about 4,000 tons of albite feldspar have been produced from a pegmatite dyke at Wog Mountain N. of the border (Hall 1959).

Small quantities of *tungsten* have been won at Mt. Bendoc, and at Fainting Range SSE. of Ensay (Thomas & Crohn 1952).

Monazite is a prominent component of alluvial deposits at Pinch Swamp Creek 5 miles N. of Bonang, though not in commercial quantities (Copland 1905).

Small *copper* lodes have been worked at Accommodation Creek, Deddick, and at Sardine and Wallaby Creeks on either side of the Bonang Highway (Dunn 1909a). Other small copper lodes are known about Limestone Ck, Ferntree Ck, the lower Timbarra R., The Basin near Buchan, and on the Snowy R. about 16 miles from Orbost; also at the Dominion Copper Mine on the head of Hospital Ck.

The *iron* ores of the Buchan-Nowa Nowa district have been extensively tested by drilling in recent years (Bell 1959), but tonnages have fallen far short of those necessary as a basis for a steel industry. One of three limonite bodies within the Buchan Caves Limestone SE. from Buchan has been quarried for 'scrubbing gas'; it is not being worked at present. (Teichert & Talent 1958). Northwards from South Buchan towards Jackson's Crossing the iron ores pass into essentially *manganese* ores, of which there are three main outcrops between The Basin and Jackson's Crossing (Kenny 1921, 1925; Thompson 1965).

The greatest potential mineral wealth of east Gippsland is in its *carbonate rocks*: the limestones and dolomites of the various bodies of Buchan Group sediments, the marbles of the Cowombat Group, and the soft limestones of the Gippsland Limestone. Green, red-brown, buff, magenta, white and flesh-coloured marbles are developed as lenticular bodies principally at Old Hut Creek, Bindi, and along Limestone and Stony Cks about 25 miles E. of Benambra. Outcrops of individual marble lenses are up to acres in extent and outcrop strongly; small quarries were opened up many years ago in the Limestone Ck-Stony Ck area (Whitelaw 1954), but these proved uneconomic due to method of working and, more particularly, prohibitive costs of transport. A small quarry was opened in the Silurian marbles between Sardine Creek and Martin's Creek about the turn of the century, but the most impressive deposit, the one at Bindi, remains untouched. *Dolomites* outcrop extensively at the base of the Buchan Caves Limestone, ranging in thickness from a few tens of feet at Bindi, Butcher's Ridge and Dead Horse Creek to a maximum thickness of around 200 ft at East Buchan where they have been quarried in small amounts for flux in steel making. Their low to moderate R_2O_3 content (sometimes as low as 0·25% Fe_2O_3) makes them potentially useful, for example, in the glass industry. The dolomite resources of the Buchan and adjacent districts is of the order of 100 million to 150 million tons. Devonian *limestones* were formerly quarried for building marble at three localities about Buchan: Commonwealth, Heath's and Cameron's quarries. Limestone of the Murrindal Limestone is presently quarried at Rocky Camp, 5 miles N. of Buchan for use in the paper industry at Maryvale. Because of ease of extraction, the Tertiary limestones exposed in valleys westwards from Orbost are an excellent source of agricultural limestone and perhaps for a future cement industry; they are presently worked on a small scale for agricultural limestone just N. of the Princes Highway on the Toorloo Arm of Lake Tyers.

Several small deposits of heavy minerals with patchy distribution of *ilmenite*, *zircon* and *rutile* are recorded from the vicinity of Cape Everard (N. H. Fisher, unpub.; G. Bell, unpub.); a possible 2000 tons of concentrate is thought to be present in the two largest deposits, the most promising being immediately E. of Point Hicks. Records from farther E., e.g. Betka R., have so far proved insignificant.

Acknowledgments

The generous assistance of a number of friends and colleagues enabled this paper to be prepared at short notice for the Royal Society of Victoria's Symposium on East Gippsland. I would like to express my thanks particularly to Mr. T. A. Darragh for stimulating discussion in the field on Cainozoic stratigraphy of eastern Victoria; to Mr. E. D. Gill for voluntarily providing information on evidence for mid-Holocene high sea levels, and on certain kaolinized and possibly laterized profiles in the area; to Miss Ingrid Mellins for criticism of the manuscript and helping sift the diffuse literature on economic geology; to Dr. D. Spencer-Jones for crticism of the manuscript, and in my absence presenting a summary of it to the Symposium; and to my wife, Joan, for typing the manuscript in my absence.

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4

BOTANICAL EXPLORATION OF EAST GIPPSLAND

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Abstract

The paper summarizes the botanical exploration which added to the known flora of Victoria the species of vascular plants, approximately 200 in number, which in this state are restricted in distribution to East Gippsland. Details are given of the original authentic Victorian record of most of these species. The principal articles and papers which have dealt with East Gippsland vegetation are noted.

Introduction

Approximately 1,400 species of vascular plants are native in East Gippsland, and about 14 per cent of these do not occur elsewhere in Victoria. Amongst the species which in Victoria are confined to East Gippsland are these groups:

1. Over 30 species belonging to near-coastal heathlands and sedge-flats. Most of these species do not occur W. of the mouth of the Snowy R., but there are a few in the Providence Ponds area to the W. of the Gippsland Lakes.
2. About 40 species belonging essentially to the warm-temperate rain-forests. This formation occurs along streams at low elevations, mainly from the lower Snowy R. eastward but with outliers as far W. as the Mitchell R. gorges NW. of Bairnsdale.
3. About 30 species on rock outcrops, mainly of the Cann River-Genoa area.
4. About ten species in dry rain-shadow areas of the upper (Victorian) Snowy R. valley.
5. About ten sub-alpine species.
6. A number of species, some widespread and some localized, in lowland dry sclerophyll forest areas.

This paper summarizes the botanical exploration which added these East Gippsland plants to the known flora of Victoria. A few typically East Gippsland species, which extend to South Gippsland, are included in the summary. Almost all the records of plants, noted in this paper, have been verified by study of the specimens concerned in the collections of the National Herbarium of Victoria. In particular, this source of reference has provided the basis for statements that certain species were collected but not recorded in the references cited.

During his term as Government Botanist of Victoria, Baron Sir Ferdinand von Mueller included in his published lists of native Victorian plants many species which had not, in fact, been discovered in this State. In some cases this was the result of errors in identification, but it was due mainly to the policy of recording as Victorian any species which had been collected near the boundaries of the State. Many of the species concerned have since been found in Victoria. Premature and erroneous records which concern the East Gippsland flora have been studied elsewhere (Wakefield, 1952). In the present paper, species which had been recorded prematurely, before their actual first discovery in Victoria, are marked with an asterisk.

Ferdinand Mueller, 1853-1861

Mueller made a number of journeys in Victoria, on four of which he came in contact with East Gippsland vegetation. Results of the first three journeys are embodied in general reports to the Victorian Government, to which are appended the first, second and third systematic lists of Victorian plants (Mueller, 1853, 1854, 1855). The other report concerning East Gippsland was accompanied by the sixth systematic list (Mueller, 1861). In the following summary, unless it is indicated otherwise, all observations and species mentioned in connection with Mueller's first, second and third journeys and that of 1860, appeared in the corresponding reports and lists. The generic and specific names in parenthesis are names used by Mueller in his various publications, and they may indicate synonyms (including *nomina nuda*) or errors in identification.

In Mueller's first general report, in September 1853, he mentioned journeying 'along the LaTrobe River', and 'several weeks travelling in the neighbourhood of Port Albert, and many excursions through Wilson's Promontory'. He collected *Gompholobium latifolium* from the Latrobe and *Banksia serrata* from the coast. He also collected *Eugenia smithii* (*Acmaena floribunda*), *Pittosporum undulatum*, *Elaeocarpus reticulatus* (*cyaneus*) and *Leptorhynchos linearis* (*nitidulus*), which four appeared in the second systematic list.

In February 1854, Mueller ascended the Cobberas Mountains and collected a number of previously unknown species and varieties of vascular plants. As a result, the Cobberas became the type locality of the following:

Hierochloe submutica F. Muell.
Agrostis muelleriana J. Vickery (*A. gelida* F. Muell.)
Scleranthus singuliflorus F. Muell. (*Mniarum*)
Phebalium phylicifolium F. Muell. (*Eriostemon phylicoides*)
Asterolasia trymalioides F. Muell. (*Eriostemon*)
Pimelea alpina F. Muell.
Pimelea curviflora var. *alpina* F. Muell. (= *P. biflora* N. A. Wakefield)
Oschatzia cuneifolia (F. Muell.) Druce (*Centella, Azorella*)
Seseli harveyanum F. Muell.
Aciphylla simplicifolia F. Muell. (*Anisotome*)
Pratia puberula F. Muell.
Leucopogon macraei F. Muell.
Olearia alpicola F. Muell. (*Eurybia*)
Olearia megaphylla F. Muell. (*Eurybia*)
Brachycome nivalis F. Muell.
Helichrysum secundiflorum N. A. Wakefield (*Ozothamnus planifolius*)
Ewartia nubigena (F. Muell.) Beauv. (*Antennaria*)
Gnaphalium umbricola J. H. Willis (*G. alpigenum* F. Muell.)

After his visit to the Cobberas, and a north-easterly excursion to the New South Wales tract of the Snowy River, Mueller returned to Omeo and from there proceeded down the Tambo River valley and then easterly to the Orbost district, which he noted as 'the most southerly locality in which palms exist in the Australian continent'. He described the flora of the lower Snowy River in these terms:

> The vegetation here assumes entirely a tropical character, with all its shady groves of trees producing dark horizontal foliage, with all those impenetrable thickets and intricate masses of parasites and climbers over running the highest trees, and with so many typical forms never or but rarely transgressing the torrid zone. The ocurrence of so many plants of a really tropical type, bears a sufficient testimony not only to the geniality of the climate but also to

the capability of the soil in the district. Transitions to the flora of New South Wales were here perceptible everywhere.

On this occasion, about the lower Snowy and Brodribb River, Mueller collected the following:

Sarcopetalum (*Cocculus*) *harveyanum*, *Cissus hypoglauca* (*australasica*), *Celastrus australis*, *Pultenaea retusa*, *Kennedia rubicunda*, *Rubus rosaefolius* (*eglantiera*), *Eucalyptus botryoides*, *Persoonia linearis*, *Morinda jasminoides*, *Bidens tripartita*, *Tylophora barbata*, *Marsdenia rostrata*, *Plectranthus parviflorus*, *Smilax australis* (*spinescens*), *Eustrephus latifolius* (*brownii*), *Livistona australis*, *Adiantum formosum* and *Pyrrosia rupestris* (*Polypodium serpens*).

Other East Gippsland species obtained during Mueller's second journey were *Callistemon citrinus* (*lanceolatus*) from Tambo River, *Scaevola ramosissima* (*hispidula*) near Sale, *Agropyron* (*Vulpia*) *pectinatum* at Boggy Creek, and *Tristania laurina* 'along rivers'. *Pteris umbrosa* and *Caustis flexuosa* appeared in the second systematic list, but the specimens concerned are not available to provide locality data; *Acacia kybeanensis* was collected near the Cobberas, and *Pomaderris discolor* and *Pteris vittata* (*longifolia*) near Bruthen and at Buchan respectively, but were not recorded in the list.

Mueller's third journey, in early 1855, was concerned mainly with the Kosciusko region of New South Wales. Afterwards, he travelled south through Wulgulmerang and Buchan, but did very little collecting on the way. He then visited the 'Palm Tree Country' again and, amongst specimens collected in the Orbost district were *Baeckea virgata* (*Camphoromyrtis pluriflora*), *Lysimachia salicifolia* (*vulgaris*), *Notelaea longifolia* (*venosa*) and *Libertia* (*Sisyrinchium*) *paniculata*. *Ripogonum album*, collected there on the second or third journey, appeared in the fourth systematic list of 1858. Returning westward along the coast, Mueller collected *Acronychia laevis* (*laurina*), *Bossiaea heterophylla*, *Muellerina* (*Phrygilanthus*) *celastroides*, *Olearia* (*Eurybia*, *Aster*) *viscosa* and *Geitonoplesium cymosum*, in the vicinity of the Gippsland Lakes.

In September 1860, Mueller went by sea to Twofold Bay, from which he travelled overland to Genoa, thence to Mallacoota and Cape Howe. He then ascended the Genoa River valley to Nungatta, and from there returned to Twofold Bay. The Genoa-Mallacoota track passed over the shoulder of Genoa Peak, in which area Mueller collected *Pomaderris lanigera* (*P. ferruginea* var. *pubescens*) and *Leptomeria acida* (neither of which is in the sixth systematic list), and *Patersonia glabrata*. The 'Entrance of the Genoa River' (= Mallacoota) yielded *Spyridium cinereum* (*Cryptandra obcordata*) (not in the sixth list), *Melaleuca armillaris*, *Angophora floribunda* (*intermedia*) and *Persoonia levis* (*salicina*, *lanceolata*). From 'abreast of Gabo Island' came specimens of *Conospermum taxifolium* and *Helichrysum elatum* (*albicans*).

From the banks of Genoa River, Mueller collected *Hibbertia dentata*, *Phebalium squamulosum* (*Eriostemon lepidotus*), *Commersonia fraseri*, *Dodonaea triquetra*, *Dendrobium speciosum*, *Dendrobium striolatum* (*milligani*), *Leptospermum emarginatum*, *Lepidosperma urophorum* and *Callistemon subulatus* (the last three of which are not in the sixth list). These nine species, and many others which Mueller collected and labelled 'Genoa River', grow together about the mouth of the granitic gorge about two miles upstream from the present township of Genoa, at the point where the old Wangarabell track swung westerly away from the river.

On Nungatta Mountain, Mueller discovered *Telopea oreades* (the Gippsland Waratah) and *Elaeocarpus holopetalus*, both of which he subsequently named.

The Period 1864-1923

In 1864-65, Norman Taylor carried out a geological reconnaissance of East Gippsland, working for some time in the Genoa area and visiting Cann River. He collected botanical specimens for Mueller but lost many of them in a flood at Genoa, and others were left at Cann River and never retrieved (Taylor, 1866). The few specimens which reached the National Herbarium include **Elaeocarpus holopetalus* from 'Drummers Creek track to Mt. Cann', and *Caustis flexuosa* from 'Canns River'.

In 1869-71, Charles Walter, who was employed by Mueller as a collector, accompanied the geodetic survey party which established beacons on prominent peaks in East Gippsland. In the Howe Ranges he found *Eucryphia moorei* and *Schelhammera undulata* (which appear in Mueller's seventh systematic list of 1874), and he discovered *Prostanthera walteri* on Mount Ellery, which species Mueller named in his honour. Besides these, Walter authenticated some of Mueller's premature records by collecting **Adiantum hispidulum* in the Howe Ranges, and **Oxylobium ilicifolium* (*trilobatum*) and **Glossodia minor* near Genoa. A specimen labelled by Mueller **Goodenia barbata* ('Genoa and Howe Ranges') without other data, was probably from Walter.

Mainly from 1879 to 1884, A. W. Howitt gathered botanical data, often through police officers working in East Gippsland. He provided specimens of *Hibbertia pedunculata* and **Acacia boormanii* (*linearis*) from the Snowy River near Deddick, and **Hierochloe rariflora* from Bonang.

At this stage a key and census of Victorian plants was published (Mueller, 1886, 1888), containing species recorded to date as well as many species prematurely or erroneously recorded for the state. However, much of Howitt's material Mueller did not study, but stored with other specimens he could not cope with. So it accumulated, and some discoveries made by Howitt and his associates were not brought to light until very recently. These included specimens of *Helichrysum adnatum* and *Pultenaea subspicata* from the Wulgulmerang-Deddick area. Howitt also provided specimens of *Pomaderris pauciflora* from Tubbut.

Later, Howitt made a study of the eucalypts of Gippsland (Howitt, 1891), amongst which he recorded *E. bosistoana* from Nicholson River and *E. maidenii* from Metung.

In the 1880s, a network of mining tracks was cut throughout East Gippsland, so that access was about equal to that provided today by Forests Commission access roads. About 1887-89, Edwin Merrall made use of such tracks to investigate the Delegate and Bemm River areas (Merrall, 1888). Amongst his botanical material were the first truly Victorian specimens of **Acacia subporosa* ('near Mount Ellery'), **Telopea oreades* ('head of Delegate River') and **Gahnia melanocarpa* ('most eastern Gippsland').

In the summer of 1888-89, Baldwin Spencer led an excursion into the area between Orbost and Bendoc and the natural history was described (Spencer and French, 1889). The large 'gebung' in the 'subtropical jungle' near Goonmirk Range was the recently described *Persoonia silvatica*.

While stationed in East Gippsland, between 1911 and 1918, Rev. A. J. Maher collected **Baeckea linifolia* and *Dendrophthoe vitellina* at Mallacoota. **Goodenia stelligera* at Genoa, and *Solanum violaceum* at Mount Drummer.

T. S. Hart, Principal, Bairnsdale School of Mines, wrote an account of the vegetation of the Bairnsdale-Gippsland Lakes area, in which were authentic Victorian records of *Thryptomene micrantha*, **Isopogon anemonifolius* and **Beyeria lasiocarpa*. (Hart 1923).

The Period 1935-1950

While on the staff of the Orbost High School, from 1935 to 1937, F. Robbins collected extensively in East Gippsland. He discovered *Cyathea leichhardtiana* and **Lastreopsis microsora* (*Aspidium tenerum*) at Mount Drummer; *Cryptostylis erecta*, *Galium binifolium* and **Leucopogon esquamatus* at Marlo; **Pomaderris ligustrina*, *P. costata* and *Korthalsella japonica* near Orbost; *Brachycome petrophila* and *Dillwynia prostrata* at Wulgulmerang; and *Galium liratum* at Nowa Nowa.

W. Hunter, a surveyor of Bairnsdale, studied the East Gippsland flora, mainly in the 1930s and 1940s. He contributed Victorian specimens of *Thysanotus junceus* and *Persoonia lucida* from near Genoa, *Chloris ventricosa* and **Glossogyne tenuifolia* from Suggan Buggan, *Helichrysum argophyllum* and *Acacia silvestris* from Nowa Nowa, *Pomaderris pallida* and **Sorghum leiocladum* (*plumosum*) from Ingeegoodbee, **Myoporum* (*Disoon*) *floribundum* from Deddick, **Leucopogon pilibundus* (*microphyllus*) from Bonang, and *Acacia maidenii* from Newmerella. At Marlo he discovered *Cryptostylis hunterana*, which was named in his honour. Hunter (1941) published an account of the flora of Suggan Buggan, part of the rain-shadow area of the upper (Victorian) Snowy River valley.

Between 1938 and 1950, N. A. Wakefield substantiated premature records of Mueller's and added other East Gippsland species to the known flora of Victoria by collecting the following:

**Ficus coronata* (*aspera*), **Eucalyptus pilularis* and *Olearia dentata* from the Howe Ranges; **Cyathochaeta diandra* from Mallacoota; **Sticherus* (*Gleichenia*) *flabellatus*, *Asplenium falcatum*, *Lastreopsis decomposita*, *Seirpus forsythii*, *Prasophyllum appendiculatum* and *Pterostylis baptistii* from the Genoa area; *Lycopodium carolinianum*, *Danthonia paradoxa*, *Panicum fulgidum*, *Lepidosperma limicola*, *Lepyrodia anarthria*, *Xyris juncea* and *Thelymitra cyanea* from Maramingo Ck; *Patersonia longifolia*, **Casuarina nana*, **Persoonia myrtilloides*, **Pultenaea altissima* (*flexilis*), *Pomaderris sericea*, *Pomaderris cotoneaster* and *Hibbertia diffusa* from the upper Genoa R.; *Stylidium laricifolium* from Wingan Inlet; **Hakea dactyloides*, **Daviesia wyattiana*, *Gompholobium glabratum*, *Pomaderris andromedifolia* and **Pomaderris ledifolia* from Mount Kaye; *Athyrium japonicum* and *Deyeuxia microseta* from Combienbar; **Deyeuxia gunniana* (*breviglumis*) and *Thelymitra retecta* from the upper Delegate R.; *Pterostylis reflexa* from Mount Raymond; *Leucopogon riparia*, *Hibbertia spathulata*, *Brachycome riparia* and *Asperula ambleia* from the lower Snowy R.; *Poa saxicola* from the Cobberas Mountains; *Polystichum formosum* from Deadcock Ck; and *Eragrostis trachycarpa* and *Cyperus polystachyos* from Providence Ponds.

Examples of warm-temperate rainforests were described and summaries given of the fern-flora and of the orchids of East Gippsland (Wakefield, 1944a, 1944b, 1950a, 1953). Series of taxonomic papers were published in the *Victorian Naturalist*, from 1939 to 1944 on pteridophytes and from 1951 to 1957 on flowering plants, and the type specimens of 30 of the new species described, including 10 in the genus *Pomaderris*, were from East Gippsland collections.

Miscellaneous Records

Other contributions relevant to this summary are as follow:

W. Sayer. *Xanthorrhoea resinosa*, 'Beyond Orbost', 1887.
W. Bauerlen. *Acacia obtusifolia*, Mount Drummer, 1887.
H. Foster. *Clematis glycinoides*, lower Snowy R., 1889.

J. St. E. D'Alton. **Marsdenia flavescens*, Lakes Entrance, 1890.

J. Cameron. *Olax stricta*, lower Cann R., 1895; **Alectryon subcinereus* (*Cupania xylocarpa*), Genoa, 1915.

R. P. Cameron. **Eupomatia laurina* and *Plectorrhiza tridentata*, Orbost, 1895; *Sarcochilus falcatus*, Cann River, 1895.

C. H. Grove. **Rubus hillii* (*moluccanus*) and *Pultenaea amoena*, Newmerella, *ca* 1895.

E. E. Pescott. *Pteris umbrosa*, Orbost, and **Leptospermum attenuatum*, Cape Conran, *ca* 1900.

A. D. Hardy. *Eucalyptus fastigata*, 'Gippsland', 1912.

H. B. Williamson. **Schoenus imberbis*, Spermwhale Head, date ?

A. H. Archibald, **Pittosporum revolutum*, Gipsy Point, 1928.

V. & B. Miller. **Scutellaria mollis*, *Prasophyllum rogersii* and **Trema aspera*, Mallacoota, 1930.

A. Birch. **Desmodium brachypodum* and **Pultenaea viscosa*, near Wentworth R., *ca* 1930.

E. K. Turner. **Notothixos subaureus*, Mallacoota, 1935.

J. H. Willis. *Logania pusilla*, Mallacoota, and *Hibbertia rufa*, near Cann River, 1948.

L. Hodge. *Westringia cremnophila* and *Boronia ledifolia*, Snowy R. gorges, *ca* 1950.

E. V. Barton, *Prasophyllum viride*, Mallacoota, 1960.

K. C. Rogers. *Acacia lucasii* and *Monotoca rotundifolia*, Nunniong Plateau, 1964.

Addendum

Carr (1962) provided evidence that Mueller's route to the Mount Hotham area in 1854 was most likely by way of the headwaters of the Dargo River, not by way of Cobungra as suggested by Wakefield (1950). In discussing this matter, Carr made these statements:

> Wakefield (1949) following a suggestion made by Barnard (1904) showed that . . . Mt. Latrobe can be identified at Mt. Loch and Mt. Hotham as Mt. Feathertop.
>
> Wakefield, relying on an old, very inaccurate sketch plan . . . dated 1864, and perhaps misled by the mention of the Mitta Mitta (actually the West Kiewa R.) assumed that Mueller crossed the Divide near the site of the present Cobungra settlement.

These statements are not in accordance with the references cited, and the 1949 is an error for 1950.

Barnard (loc. cit.) concluded that Mueller 'instead of ascending Feathertop and naming it Hotham, really ascended our Bogong and bestowed that name (Hotham) upon it, while his Latrobe is either Mt. Wills . . . or Mt. Nelson'. Wakefield (1950) stated that 'these contentions cannot be supported' and reached the conclusion that Mt. Feathertop is Mueller's 'Hotham' and Mt. Loch is Mueller's 'Latrobe'.

Wakefield (loc. cit.) published an accurate map compiled from modern topographical plans, with a small sketch inset at a corner, and the text indicated the source of the sketch and that it was presented to illustrate the application, in 1864, of certain place names. Wakefield stated that the stream which Mueller referred to as the upper Mitta was 'certainly the west branch of the Kiewa River'.

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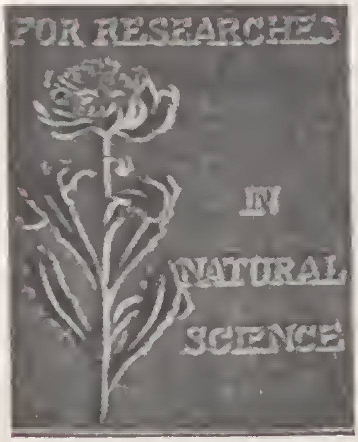

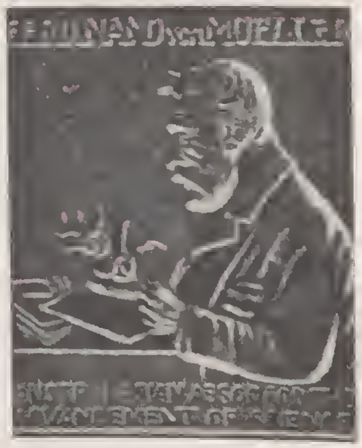

The Mueller Memorial Medal

The Mueller Memorial Medal draws together the three names pre-eminent in early scientific exploration of East Gippsland, Mueller, Spencer and Howitt.

After Baron von Mueller's death, 1896, a committee from the Australian scientific societies, including the Royal Society of Victoria, chose this form of memorial for the famous botanist, using money subscribed by his friends and admirers.

The beautiful bronze medal is awarded by the Australian and New Zealand Association for the Advancement of Science 'not more frequently than every second year, to the author of the most important contribution, or series of contributions, to natural knowledge, published originally within His Majesty's Dominions . . . preference being given to work referring to Australia.'

The design for the medal was executed by Sir Baldwin Spencer. It shows von Mueller with an acacia spray in his hand, and on the obverse, a waratah. (Spencer's early sketch of the East Gippsland waratah, 1889, is shown on page 76 of this Volume.)

The first award of the medal, 1904, was made to A. W. Howitt 'for his distinguished services as an ethnologist and geologist, and for his exploration in Australia.'

5

BOTANY OF EAST GIPPSLAND

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WITH APPENDIX BY J. H. WILLIS

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Abstract

The distribution of the rich vascular flora of East Gippsland is discussed, special attention being given to the plants characteristic of the warm coasts of New South Wales and Queensland, the dry areas inland from the Great Divide and the cool sub-alpine regions of Australia. An account is given of the most important of the wide range of plant communities found in this part of Gippsland. This includes rainforest, sclerophyll forest, woodlands, scrubs, thickets and heaths, and the variation of these communities with altitude is described. The effects of fire are considered wherever possible.

The fascination of East Gippsland to the botanist lies in the fact that it is the meeting ground of different floras from the north, west and south.

Since the habitat, east of the line joining the Mitchell and Murray headwaters, ranges from sub-alpine mountains and montane valleys to humid coastal flats, it is not surprising that the flora is a rich one. Of the vascular plants, 1200 (roughly half the state's total) occur within the region which is defined by the Symposium as E. of the Tambo-Mitchell Rivers and which makes up only 7 per cent of the area of the state. Two hundred species and 37 genera do not extend further W. than the Tambo and Mitchell rivers. The *Dendrobium* orchids are a notable example of this restriction. About 36 eucalypts, or half of the state's complement, grow in East Gippsland, although only eight are limited in Victoria to this sector. The same general picture applies to the genus *Acacia*.

Ferns are richly developed in East Gippsland; 80 out of the 92 species occur here, although only 10 per cent are restricted to this area. Mosses are also numerous (at least 150 species); many extend from New South Wales and from other regions of Victoria.

Distribution of Taxa

The plant geography of East Gippsland shows many interesting patterns of distribution. Concentric distributions radiate from the Cape Howe region, from the dry valleys of the north and from the west. A great many species distributions overlap in this south-east corner of the continent. There is a well defined element of the vegetation comprising species that are more numerous further north along the coasts of New South Wales and Queensland (Patton 1930). This so-called 'warm element' extends westwards to a varying degree; this can be seen from the following list which shows the western limits of relevant species:

(i) Howe Range
Eucryphia moorei, *Trema aspera*

(ii) Mallacoota Inlet and Genoa Gorge
Ficus coronata, *Santalum obtusifolium*, *Alectryon subcinereus*, *Galium binifolium*, *Logania pusilla*

(iii) Wingan Inlet area
Angophora floribunda, Eucalyptus gummifera, Stylidium laricifolium
(iv) Bairnsdale and Mitchell River gorge
Eucalyptus botryoides, Tristania laurina, Marsdenia rostrata
(v) The Macalister River Valley
Eucalyptus andreana, E. bosistoana
(vi) Wilsons Promontory
Eugenia smithii, Elaeocarpus reticulatus, Banksia serrata, Kunzea ambigua, Eucalyptus muelleriana, Melaleuca armillaris
(vii) Western Port
Pittosporum undulatum
(viii) Healesville-Warburton-Dandenong Range area
Fieldia australis, Pyrrhosia rupestris, Eucalyptus globoidea, E. nitens.
(ix) Coimadai area and Brisbane Ranges
Eucalyptus sieberi, Grevillea chrysophaea.

Species which are normally found in relatively low rainfall areas on the plains and foothills on the inland side of the Great Divide are also found in the rain shadow area of the middle tract of the Snowy River System. This 'dry element' of the vegetation extends a variable distance southwards from the region of the geodetic border. Illustrations of such distributions are:

(i) The Suggan Buggan and upper Snowy River valleys
Callitris columellaris, C. endlicheri, Eucalyptus albens, Acacia boormanii, Boronia ledifolia, Cymbopogon refractus
(ii) The Mitchell River gorge
Brachychiton populneus

Many species, such as *Eucalyptus sideroxylon, E. polyanthemos* and *Acacia mitchellii* (Providence Ponds), extend from western and central Victoria into East Gippsland. *Micromyrtus ciliatus, Kunzea parvifolia* and *Phebalium glandulosum* are heathy species which reach the Snowy gorge area from their usual habitats of the Grampians-Little Desert or the Big Desert. The Snowy River is the site of the only endemic species for the region which, according to Wakefield (1957), are *Leucopogon riparius, Westringia cremnophylla* and *Hibbertia spathulata.*

The cool element in the vegetation is represented by higher altitude species from the sub-alpine terrain to the NW., from wet central district mountains and from Tasmania. Species such as *Atherosperma moschatum, Podocarpus lawrencei, Drimys lanceolata, Leucopogon macraei* and *Libertia paniculata* occur in higher altitude areas in the mountains of this region. The absence of *Nothofagus* and the almost complete lack of *Eucalyptus regnans* (there are pockets on the Nuniong Plateau) are very notable features. The waratah *Telopea oreades* is a link with the floristics of New South Wales and Tasmania, where the related species occur. East Gippsland provides enigmatic distributions such as those of the Japanese fern, *Athyrium japonicum*, and the mistletoe *Korthalsella japonica.* It is also a centre of diversity of the shrub genus *Pomaderris*, which has 17 species in this area.

The botanical drawings accompanying this paper, and other botanical drawings in the volume, were made by Sir Baldwin Spencer, and are published by courtesy of the Field Naturalists' Association of Victoria. They illustrate his well-known paper (with C. French, F.L.S.), 'Trip to Croajingolong'. (Vict. Nat. 1889), descriptive of the exploratory journey made with four companions to East Gippsland, 1888, the year after Spencer arrived in Australia as Professor of Biology at the University of Melbourne.

A group of full-grown palms growing by the side of Cabbage Tree Creek.
(*W. B. Spencer, 1889.*)

Plant Communities

Apart from the species present, a very distinctive feature of East Gippsland vegetation is the great range and variety of its plant communities. In the brief account of these which is given below, the classification of formations follows Wood and Williams (1960) and the zones and ecology of forest types are based on those of Incoll (1940).

1. RAINFOREST

(a) LOWLAND (less than 1500 ft)

For a Victorian, the most conspicuous feature is the complexity of the coastal gully vegetation. The so-called 'jungles' have dense trees and tumbling masses of ropey lianes. To a Queenslander, this is a depauperate and simplified version of the familiar subtropical rainforest of the north. The East Gippsland rainforest could be termed warm temperate or, according to Webb's classification (1959), a microphyll fern forest. A handful of tree species make up the tree canopy, which is more or less continuous and dense.

Eugenia smithii, which reaches 60 to 90 ft in height, is the most characteristic tree. It is associated with *Tristania laurina* along creeks and river banks and with other less important trees such as *Rapanea howittiana*, *Acronychia laevis* and *Elaeocarpus holopetalus*. Many trees show abundant regeneration. On the Brodribb and Cabbage Tree Cks. near Marlo, patches of rainforest contain the palm *Livistona australis*, which is separated from the main areas in New South Wales by some 200 miles. These palms reach heights of 72 ft and are regenerating; they appear to be fire resistant to some extent. The blackwood, *Acacia melanoxylon*, often co-dominates with *Eugenia* in rainforests. The lianes form a suite of 17 species, 4 of which are wiry. Most occur only to the east of the Mitchell Gorge, but 4 species (including *Parsonsia brownii* and *Pandorea pandorana*) extend west to gullies near Melbourne, although they are not particularly prolific there. All species extend to New South Wales and most to Queensland. *Marsdenia rostrata*, *Smilax australis*, *Cissus hypoglauca*, *Eustrephus latifolius* and *Clematis glycinoides* are quite common; other genera include *Rhipogonum*, *Sarcoperalum* and *Tylophora*.

Ferns are usually prolific, and up to five species of tree fern may be found in a single stand, e.g. Mt. Drummer (Wakefield 1944). Ferny epiphytes are often common, and mosses locally abundant.

This warm temperate rainforest occurs on rich alluvial loams and on friable soils on southern seaward slopes of coastal hills such as Mt. Cann and Mt. Drummer.

Many areas have been severely damaged by fire; some smaller pockets have been obliterated (N. Wakefield—pers. comm.). Dense shrubs and small trees such as *Pomaderris* and *Acacia* spp. usually follow in the wake of fires. At Lake Curlip there is evidence of primary succession from submerged fresh water vegetation to reed beds (*Phragmites*), ti-tree (*Melaleuca*) thicket and *Eugenia* rainforest. Even so, the occurrence of an old overstorey of *Eucalyptus botryoides* and soil charcoal in the rainforest indicates prior destruction by fire. Fire has permitted the extension of reed bed *Phragmites* into *Melaleuca ericifolia* areas. Similarly, *Eugenia* may be replaced by *Melaleuca* thicket if regularly burnt.*

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* An account of the ecology of this area will be published by Cowling and Ashton at a later date.

(b) MONTANE (1500-3000 ft)

Above 1500-2000 ft, *Eugenia smithii* is replaced by *Atherosperma moschatum*, and *Pittosporum undulatum* by *P. bicolor*. *Elaeocarpus holopetalus* and *Acacia melanoxylon* remain, and shrubs such as *Drimys* and *Telopea oreades* are abundant. Lianes such as *Parsonsia* and *Smilax* are sparse or absent. *Dicksonia antarctica* becomes the chief tree fern in the community. Mosses are very conspicuous on trunks, logs and rocks. This is then the cool temperate rainforest, akin to that in southern Victoria, Tasmania and high altitude New South Wales.

Nothofagus is conspicuous by its absence. A curious community of dense mossy scrub—*Drimys*, *Telopea*, *Notelaea* and *Prostanthera lasianthos*, with emergent *Podocarpus lawrencei* 30-35 ft high—occurs on Goonmirk Range at 3000 ft. This is an odd form of rainforest thicket probably controlled by cloud incidence and the virtual absence of fire.

2. SCLEROPHYLL FOREST

The bulk of the vegetation of the region is sclerophyll forest dominated by species of *Eucalyptus*. More species contribute to stands here than in other parts of Victoria and sometimes five or six species may be encountered in quite a short distance.

(i) *Wet Sclerophyll Forest*

(a) LOWLAND

In the wettest areas, 40″ per annum and above, and sheltered areas with more than 30″ per annum, wet sclerophyll forests may be found with trees 150-210 ft high and a dense, broad-leaved understorey with abundant ferns. In many cases these flank the rainforest, and clear evidence exists (e.g. at Cabbage Tree Creek) that burning has permitted them to spread at the expense of the rainforest. *Eucalyptus cypellocarpa*, *E. botryoides* and *E. muelleriana*, with understoreys of *Pomaderris* and *Bedfordia*, have regenerated following incineration of *Eugenia* rainforest. *Eugenia* is at present regenerating prolifically into these areas.

In the foothills areas, blue gum (*E. maidenii*), *E. fastigata* and *E. andreana* occur in wet sclerophyll forest; in some cases mature eucalypts occur over mature rainforest, indicating a history of catastrophes.

(b) MONTANE

In the montane belt at Mt. Ellery, *E. nitens*, *E. fastigata*, *E. obliqua* and *E. delegatensis* form wet sclerophyll forest with dense shrubs of *Telopea*, *Coprosma* and *Drimys*. On the Errunundra Plateau, a fully developed *Atherosperma* forest occurs beneath a mature stand of *E. nitens*, indicating an ecological story similar to the one in the lowlands.

At 4500-5500 ft, where rainfall is high (>40″), *E. delegatensis* occurs, but may form a grassy forest due to the paucity of shrub development.

Soils of the montane forests vary from podzolic to friable red/brown loams with much organic matter. They are often deep, and show good moisture retention.

(ii) *Dry sclerophyll forest*

On leached sands or sandy loams over clays and on drier aspects in moderate rainfall areas (30″ p.a.), a dry sclerophyll forest 70-120 ft high is developed. The undergrowth consists of small-leaved, sclerophyllous leguminous and proteaceous shrubs such as *Acacia*, *Daviesia*, *Platylobium*, *Banksia*, *Hakea* and

Shingle bank succession through herbs, shrubs, *Leptospermum* and then *Callistemon* to riparian wet sclerophyll or dry sclerophyll forest occurs on the larger streams. This will probably continue to a stable state along the Snowy R. now that floods are controlled by the Snowy Hydro-electric Scheme. Sheltered chasms (e.g. Stradbroke Chasm) in this dry belt provide niches for fern gully species (*Australina, Dicksonia* and several other ferns) many miles from main areas.

(c) SUB-ALPINE

At high altitudes, e.g. Cobberas to 6000 ft, *E. pauciflora* forms a sub-alpine woodland with snow grass (*Poa australis*) and alpine shrubs such as *Phebalium, Prostanthera* and *Hakea microcarpa.*

This vegetation type is just included in the defined region of East Gippsland and appears to be a relatively dry example of the highland vegetation.

4. SCRUB AND THICKET

On rocky outcrops, xerophytic scrub develops along the Snowy and Suggan Buggan valleys. *Acacia silvestris, Eriostemon trachyphyllus, Phebalium* and *Cheilanthes* characterize this vegetation type. *Psilotum* is an interesting but very rare species in this habitat.

Other areas of scrub which are unfavourable to taller vegetation are on coastal dunes, where *Leptospermum laevigatum, Correa alba* and *Leucopogon parviflorus* occur in the salt-sprayed zone.

The swamp areas support thickets and scrubs dominated by *Melaleuca ericifolia* and sedges.

5. HEATH

(a) LOWLAND

Areas subject to seasonal waterlogging because of a hard clay pan may permit the growth of woodlands, *E. cephalocarpa* tree heath or merely swamp heath dominated by multititudinous sedges, rope rushes and sclerophyll shrubs such as *Leptospermum* and *Hakea.* Club mosses such as *Selaginella* and species of the carnivorous genera *Drosera* and *Utricularia* are often present.

Species-rich sandy heaths, dry and wind-exposed in coastal areas from Mallacoota to Marlo, are dominated by *Leptospermum myrsinoides—Casuarina pusilla,* with many legumes, *Xanthorrhoea,* sedges, grasses and orchids. Such heaths are frequently burned; hence the height of the dominants and the species composition are very variable.

(b) MONTANE

Wet heaths are found at higher altitudes in swampy conditions; they show transitions to alpine and sub-alpine bog heaths. At 4500 ft *Sphagnum* is common, with the herbaceous *Gentianella* and shrubs of *Richea, Epacris* and *Callistemon.*

The vegetation pattern in East Gippsland is therefore probably the most complex in the state, due to the diversity of habitat and burning pattern, and the fact that species from several different floristic regions are competing for sites. The geography of species distribution in some cases suggests a westward advance from the lowlands of the south-east corner of the continent. For example, around Melbourne and the Dandenong Ranges, *Pittosporum undulatum* is showing evidence of rapid spread well beyond its original area. On the other hand, the disjunct distributions of rainforest pockets suggest that some species such as *Eugenia smithii* may have been more widely distributed in the past.

Persoonia. The geebung, *Persoonia linearis*, is a characteristic shrub of many of these forests. Bracken is often common.

The commonest forest is dominated by *E. sieberi* (silver top) and *E. globoidea* (white stringy-bark) and occurs on ridges consisting of granites, Ordovician slates and Tertiary and Pleistocene sediments. There are many variants of this forest, depending on aspect, drainage, clay content of the soil, altitude and geography. In the far eastern sector, *E. gummifera* and *Angophora floribunda* join the above species.

Where humus podzol soils have developed on deep sands, a somewhat lower forest may consist of *E. globoidea*, *E. botryoides* and *E. consideniana* with *Banksia serrata* forming a conspicuous second storey. Where the soil is still well drained but includes greater amounts of clay, *E. muelleriana* and *E. botryoides* may dominate a forest transitional to wet sclerophyll forest. On well drained ridges, *E. sideroxylon* may dominate individual stands, or it may form forest mixtures with *E. cypellocarpa*—*E. obliqua* associations and thus show a sharp contrast with the situation in central Victoria.

3. WOODLANDS

(a) LOWLAND

Where shallow skeletal soils are associated with very poor or excessive drainage, or where exposure to wind near the coast is great, or where rainfall is relatively low (20″), the tree form is reduced and the stand is more open. The resulting woodland formations (40-80 ft high) may be composed of depauperate forest species or of completely different species.

Sclerophyll woodlands of *E. globoidea* and *E. botryoides*, with *Banksia*, sclerophyll shrubs and bracken, occur on poor soils in exposed coastal areas. On skeletal soils on sandstone and rhyolite, *E. macrorrhyncha*, *E. polyanthemos* and *E. goniocalyx* may form woodlands with a shrubby undergrowth of *Brachyloma* and *Cassinia*. On thin but relatively fertile limestone soils at Buchan, *E. viminalis* and *.E melliodora* occur with a grassy herbaceous floor dominated by *Themeda* tussocks and occasional shrubs of *Bursaria spinosa*.

(b) MONTANE

On fair to rich soils at higher altitudes (2500 ft)—such as the Wulgulmerang tableland—*E. pauciflora* and *E. rubida* occur with *E. stellulata* (on wetter areas) and *E. camphora* (in water-logged sites). A grass sward includes *Themeda*, *Poa* and *Danthonia*. This area is cold, snowy, frosty in winter, and dry; the annual rainfall is 25″.

A spectacular change to drier valleys with a rainfall of less than 20″ per annum occurs in the Snowy, Suggan Buggan and Deddick River valleys, where woodlands dominated by *Callitris* and/or *E. albens* are found. These are isolated from the main areas on inland slopes of the divide in New South Wales.

Most of these stands are below 2,000 ft. Dense stands of *Callitris columellaris*, with little undergrowth or grass, occur on the N. and W. slopes. *Callitris* is mixed with the eucalypt on E. and SW. slopes, and the eucalypt forms pure stands on S. and SE. slopes.

Callitris stands are possibly 50-80 years old and are remnants of mature grassy woodland. Fire-scarred veterans are 66 ft high. *Callitris* regenerates from seed after fire, whereas eucalypts coppice readily. *Callitris* shows slow germination, rapid initial root penetration and slow growth. Signs of invasion of eucalypt stands by *Callitris* can be seen in the post-myxomatosis era.

Until more is known about dispersal, and the fossil record of the climatically turbulent Pleistocene period, little can be done to illuminate the picture. One thing is certain: caution should be used in any causative correlation with the habitat until the time factor is fully taken into account.

Acknowledgments

We wish to thank Mr. N. A. Wakefield for helpful discussions on the botany of East Gippsland and for the use of his personal notes. We would also like to thank Professor J. S. Turner for his criticisms, and Dr. Suzanne Duigan for her assistance with the manuscript.

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A waratah (*Telopea oreades*) growing at the head of a gully on Mount Ellery.
(*W. B. Spencer, 1889.*)

APPENDIX

CENSUS OF VASCULAR FLORA INDIGENOUS TO EAST GIPPSLAND

By J. H. WILLIS

National Herbarium of Victoria

The following enumeration of families, genera and species in the ferns, conifers and monocotyledons conforms to the author's arrangement in *A Handbook to Plants in Victoria* Vol. 1 (1962), while the families of dicotyledons are grouped according to the order of Engler & Prantl's *Die Natürlichen Pflanzenfamilien* (1887-1902). Known localities are appended for those species having a more restricted range, while plants confined to pockets of 'jungle' (southern extensions of subtropical rain forest) are indicated by the prefixing sign (†). The total number of species listed for East Gippsland is 1435, of which about 200 are not to be found elsewhere in this State.

For the purposes of this list, East Gippsland includes all that part of Victoria on the southern side of the Great Dividing Range and eastward from the Mitchell River valley and its tributary, the Wentworth River. If, as for other papers of the Symposium, East Gippsland be limited to the region lying east of the 148th parallel of longitude, then its known indigenous flora still comprises 1390 species.

FERNS AND FERN ALLIES

OPHIOGLOSSACEAE

Ophioglossum coriaceum A. Cunn.—Sperm Whale Head, Store Ck near Deptford, Suggan Buggan
Botrychium lunaria (L.) Swartz—Reedy R. cliffs, Ram's Horn SW. of Cobberas, Ingeegoodbee R. (subalpine)
B. australe R. Br.—Lower Snowy R., Noorinbee, Genoa

OSMUNDACEAE

Todea barbara (L.) T. Moore

SCHIZAEACEAE (damp, near-coastal heaths)

Schizaea fistulosa Labill.
S. bifida Willd.
S. asperula N. A. Wakefield

GLEICHENIACEAE

Gleichenia circinnata Swartz
G. microphylla R. Br.
†*Sticherus flabellatus* (R. Br.) H. St. John—near Genoa Peak, W. slopes of Howe Ra.
S. tener (R. Br.) Ching
S. lobatus N. A. Wakefield

HYMENOPHYLLACEAE

Hymenophyllum cupressiforme Labill.
H. peltatum (Poir.) Desv.—Mt. Ellery
Mecodium flabellatum (Labill.) Copeland
M. rarum (R. Br.) Copeland
M. australe (Willd.) Copeland
Polyphlebium venosum (R. Br.) Copeland
†*Macroglena caudata* (Brackenridge) Copeland—Mt. Drummer, Howe Ra.

CYATHEACEAE

Cyathea cunninghamii Hook. f.—Young's Ck at Orbost, Bungywarr Ck at Combienbar, Mt. Drummer
C. marcescens N. A. Wakefield—Combienbar district, Mt. Drummer
C. australis (R. Br.) Domin
†*C. leichhardtiana* (F. Muell.) Copeland—'Fairy Dell' near Bruthen, Mt. Drummer, lower Wingan R.

DICKSONIACEAE

Dicksonia antarctica Labill.

DENNSTAEDTIACEAE

†*Dennstaedtia davallioides* (R. Br.) T. Moore
Culcita dubia (R. Br.) Maxon
Hypolepis rugosula (Labill.) J. Sm.
H. australis N. A. Wakefield—Arte R.
H. punctata (Thunb.) Kuhn
H. muelleri N. A. Wakefield
Pteridium esculentum (Forst. f.) Nakai
Histiopteris incisa (Thunb.) J. Sm.

LINDSAYACEAE

Lindsaya linearis Swartz
L. microphylla Swartz—Karlo Ck near Mt. Drummer, Upper Cann R. Valley

ADIANTACEAE

Adiantum aethiopicum L.
†*A. formosum* R. Br.—Pipeclay Ck near Orbost, Cann R. near Noorinbee
A. hispidulum Swartz
†*Pteris umbrosa* R. Br.
P. vittata L.—on limestone of Buchan & Murrindal districts

P. tremula R. Br.
Pellaea falcata (R. Br.) Fée
Cheilanthes tenuifolia (Burm. f.) Swartz
C. distans (R. Br.) Mett.—Buchan, Suggan Buggan, Noorinbee & Mt. Kaye, Genoa

Grammitidaceae

Grammitis billardieri Willd.—Mt. Ellery, Mt. Kaye, Genoa Peak & Upper Genoa R.
Ctenopteris heterophylla (Labill.) M. D. Tindale—Combienbar, Cann, Wingan & Genoa Rivers, Mt. Drummer

Polypodiaceae

†*Pyrrosia rupestris* (R. Br.) Ching
Microsorium diversifolium (Willd.) Copeland
†*M. scandens* (Forst. f.) M. D. Tindale

Aspleniaceae

Asplenium obtusatum Forst. f.—Cape Everard, Ram Head & E. head of Wingan Inlet, 5 miles SW. of Mallacoota
A. falcatum Lam.—2 miles SE. of Genoa (perhaps extinct)
A. flabellifolium Cav.
A. trichomanes L.—Bindi, Forlorn Hope Ck, Buchan, Murrindal R., Boundary Ck near Wulgulmerang (mostly on limestone)
A. bulbiferum Forst. f.
A. flaccidum Forst. f.
Pleurosorus rutifolius (R. Br.) Fée

Thelypteridaceae

Cyclosorus parasiticus (L.) Farwell—Buchan (on limestone)

Athyriaceae

Athyrium australe C. Presl
A. japonicum (Thunb.) Copeland—Buchan, Brodribb R. (?extinct), Upper Combienbar R.
Cystopteris filix-fragilis (L) Bernh.—Native Dog Gorge & Forlorn Hope Ck in Upper Buchan R. Watershed, Little R. Falls near Wulgulmerang (all between 2000 & 3000 ft alt.)

Aspidiaceae

Rumohra adiantiformis (Forst. f.) Ching
Polystichum proliferum (R. Br.) C. Presl
P. formosum M. D. Tindale—Deadcock Ck near Mitchell R., W Tree Ck near Gelantipy, Murrindal R., Yambulla Ck near Upper Genoa R.
Lastreopsis decomposita (R. Br.) M. D. Tindale—Mallacoota Inlet opposite Gipsy Point
†*L. microsora* (Endl.) M. D. Tindale
L. shepherdii (Kunz ex Mett.) M. D. Tindale

Blechnaceae

Blechnum cartilagineum Swartz
B. patersonii (R. Br.) Mett.
B. nudum (Labill.) Mett. ex Luerss.
B. aggregatum (Colenso) M. D. Tindale—Bindi, Mt. Ellery, Combienbar, Arte R.
B. procerum (Forst. f.) Swartz
B. minus (R. Br.) Ettingsh.
B. fluviatile (R. Br.) E. J. Lowe ex Salomon
B. penna-marina (Poir.) Kuhn—subalpine tracts of Nunniong Plateau, Cobberas & Wombargo and Upper Delegate R.
Doodia caudata (Cav.) R. Br.
D. media R. Br.
†*D. aspera* R. Br.

Marsileaceae

Marsilea hirsuta R. Br.—Bairnsdale (on mud)

Azollaceae (aquatic)

Azolla pinnata R. Br.
A. filiculoides Lam.—Mille Inlet on Brodribb R.

Lycopodiaceae

Phylloglossum drummondii Kunze
Lycopodium varium R. Br.—Mt. Kaye & Genoa Peak (on granite)
L. deuterodensum Herter—Nowa Nowa, Orbost, Genoa, Cape Howe
L. fastigiatum R. Br.—subalpine tracts of Nunniong Plateau and Upper Delegate R.
L. laterale R. Br.
L. carolinianum L.—Maramingo Ck (6 miles NE. of Genoa)

Selaginellaceae

Selaginella uliginosa (Labill.) Spring
S. gracillima (Kunze) Alston—Ewing's Morass near Lake Tyers, Marlo & Coringle

Isoetaceae

Isoëtes humilior F. Muell. ex A. Br.—Genoa R. Gorge & Little R. Falls near Wulgulmerang

Psilotaceae

Psilotum nudum (L.) Griseb.—Ballantyne Hills near Suggan Buggan
Tmesipteris billardieri Endl.
†*T. parva* N. A. Wakefield—Mt. Drummer & Howe Ra.

†*T. ovata* N. A. Wakefield—Mt. Drummer & Howe Ra.

CONIFERS

PODOCARPACEAE

Podocarpus lawrencei Hook. f.—alpine & subalpine at Cobberas, Wombargo Ra. & Goonmirk Ra.

CUPRESSACEAE

Callitris columellaris F. Muell.—Upper Snowy, Deddick & Suggan Buggan R. valleys (rain-shadow belt)
C. rhomboidea R. Br. ex L. C. Rich—Wingan Inlet & Howe Ra.
C. endlicheri (Parl.) F. M. Bailey—Upper Snowy R., Lower Deddick R. & Upper Gattamurrh Ck

MONOCOTYLEDONS

TYPHACEAE

Typha sp. [identity needs to be checked]

SPARGANIACEAE

Sparganium ramosum Huds.—Orbost

POTAMOGETONACEAE (aquatic)

Potamogeton tricarinatus F. Muell. & A. Bennett ex A. Bennett
P. perfoliatus L.—Tambo R.
P. lucens L.—Tambo R.
P. crispus L.—Bendoc, Wulgulmerang
P. ochreatus Raoul—Bairnsdale, Orbost, Cann R., Little R. near Wulgulmerang, Murrindal R.

ZOSTERACEAE (marine)

Zostera muelleri Irmisch ex Aschers.

RUPPIACEAE (aquatic)

Ruppia sp. [identity needs to be checked] —Bairnsdale, Brodribb R., Betka R., Mallacoota Inlet

ZANNICHELLIACEAE (aquatic)

Cymodocea antarctica (Labill.) Endl.—(marine)
Lepilaena bilocularis T. Kirk—Lower Mitchell R.

JUNCAGINACEAE

Triglochin procera R. Br. (aquatic)
T. striata Ruiz & Pav.
T. minutissima F. Muell.—Sperm Whale Head

ALISMATACEAE

Alisma plantago-aquatica L.—Lake King, Bairnsdale, Orbost, Cann R.
Damasonium minus (R. Br.) Buch.—Bairnsdale, Orbost

HYDROCHARITACEAE (aquatic)

Ottelia ovalifolia (R. Br.) L. C. Rich.—Bairnsdale to Lakes Entrance, Orbost district, near Genoa
Vallisneria spiralis L.—Bairnsdale district, Buchan, Orbost, Upper Snowy R. at Willis

GRAMINEAE

Microlaena stipoides (Labill.) R. Br.
Tetrarrhena acuminata R. Br.—Reedy & Maramingo Cks near Prince's Highway
T. distichophylla (Labill.) R. Br.—Marlo, Wingan Inlet, Maramingo Ck
T. juncea R. Br.
Puccinellia stricta (Hook. f.) C. Blom—Marlo, Mallacoota Inlet
Distichlis distichophylla (Labill.) Fassett —Sperm Whale Head, Lakes Entrance, Cape Conran, Coringle
Poa poiformis (Labill.) Druce—Gabo Is., Wingan Inlet, Ram Head, Cape Conran
P. australis, sp. agg.
P. tenera F. Muell. ex Hook. f.
P. saxicola R. Br.—Cobberas (alpine)
Festuca littoralis Labill.—Coringle, Cape Conran, Tamboon Inlet, Ram Head
F. muelleri J. W. Vickery—Cobberas, Mt. Ellery, Mt. Tingaringy (subalpine)
F. eriopoda J. W. Vickery—Maramingo Ck (6 miles NE. of Genoa)
F. asperula J. W. Vickery (montane to subalpine)
F. hookeriana F. Muell. ex Hook. f.—Wulgulmerang & Cobberas (subalpine)
Dryopoa dives (F. Muell.) J. W. Vickery —Suggan Buggan
Glyceria australis C. E. Hubbard—Wulgulmerang, Bendoc, Cann R.
Agropyron scabrum (Labill.) Pal. Beauv.
A. velutinum Nees—Nunniong Plateau
A. pectinatum (Labill.) Pal. Beauv.
Amphibromus neesii Steud.—Cann R.
Trisetum spicatum (L.) Richt.—Nunniong Plateau, near Suggan Buggan, Cobberas
Deschampsia caespitosa (L.) Pal. Beauv. —Delegate R.
Hierochloë redolens (Soland. ex Vahl) Roem. & Schult.—Cobberas, Upper Delegate R.
H. rariflora Hk. f.
Dichelachne crinita (L. f.) Hook. f.
D. sciurea (R. Br.) Hook. f.
Deyeuxia gunniana (Nees.) Benth.—Upper Delegate R. at Bidwell (subalpine)
D. brachyathera (Stapf) J. W. Vickery—Cobberas & Nunniong Plateau (alpine)
D. quadriseta (Labill.) Benth.

D. monticola (Roem. & Schult.) J. W. Vickery

D. frigida F. Muell. ex Benth.—Cobberas, Wulgulmerang

D. densa Benth.—Cape Conran, Maramingo Ck (6 miles NE. of Genoa)

D. carinata J. W. Vickery—Cobberas (alpine)

D. minor F. Muell. ex Benth.—flats of Lower Cann R. & Reedy Ck

D. rodwayi J. W. Vickery—Mt. Ellery, Goonmirk Ra., Howe Ra.

D. crassiuscula J. W. Vickery—Cobberas & Wombargo Ra. (alpine)

D. benthamiana J. W. Vickery—Murrungowar Mtns.

D. microseta J. W. Vickery—Combienbar

D. scaberula J. W. Vickery—Murrungowar Mtns. & Mt. Ellery

D. contracta (F. Muell. ex Hook. f.) J. W. Vickery—Bairnsdale district

D. sp.—[*aff. D. angustifolia* J. W. Vickery] Ballantyne Hills near Suggan Buggan

Agrostis hiemalis (Walt.) Britton et al.

A. muelleriana J. W. Vickery—Cobberas (alpine)

A. parviflora R. Br.—Upper Delegate R. at Bidwell (subalpine)

A. venusta Trin.—Cobberas & Nunniong Plateau (subalpine)

A. billardieri R. Br.—Lakes Entrance, Ram Head, Mallacoota

A. aemula R. Br.—Cann R. valley

A. avenacea J. F. Gmel.

Echinopogon ovatus (Forst. f.) Pal. Beauv.

Pentapogon quadrifidus (Labill.) Baill.

Zoysia macrantha Desv.—Cape Conran, Wingan Inlet, Betka R. mouth

Tripogon loliiformis (F. Muell.) C. E. Hubbard—Suggan Buggan

Eragrostis elongata (Willd.) J. F. Jacq.—plains near Bairnsdale

E. brownii (Kunth) Nees ex Steud.

Chloris truncata R. Br.—Bairnsdale, Suggan Buggan

C. ventricosa R. Br.—Suggan Buggan

Cynodon dactylon (L.) Pers.

Sporobolus virginicus (L.) Kunth—(coastal)

Phragmites communis Trin.

Enneapogon nigricans (R. Br.) Pal. Beauv.—Suggan Buggan, Upper Snowy R., Lower Bendoc, Upper Genoa R.

Danthonia paradoxa R. Br.—Maramingo Ck (6 miles NE. of Genoa)

D. pallida R. Br.

D. longifolia R. Br.—Tambo R., Wulgulmerang, Wingan Inlet, Howe Ra.

D. semiannularis (Labill.) R. Br.—Orbost, Wulgulmerang

D. induta J. W. Vickery—Suggan Buggan, Upper Snowy R.

D. alpicola J. W. Vickery—Cobberas, Mt. Tingaringy (subalpine)

D. eriantha Lindl.

D. setacea R. Br.—Kalimna

D. purpurascens J. W. Vickery—Bairnsdale district

D. caespitosa Gaudich.

D. laevis J. W. Vickery—Cobberas, Wulgulmerang

D. racemosa R. Br.

D. pilosa R. Br.

D. penicillata (Labill.) Pal. Beauv.

D. nudiflora P. F. Morris—Cobberas, Nunniong Plateau (alpine)

Aristida ramosa R. Br.—Suggan Buggan, Upper Snowy R., Deddick R. (rain-shadow belt)

Anisopogon avenaceus R. Br.—near-coastal

Stipa teretifolia Steud.—Cape Conran, Ram Head & Wingan Inlet, Mallacoota

S. semibarbata R. Br.—Bairnsdale, Suggan Buggan

S. hemipogon Benth.—Cape Conran, Genoa R. gorge, Mallacoota

S. aristiglumis F. Muell.—Suggan Buggan

S. blackii C. E. Hubbard—Bairnsdale, Kalimna, Suggan Buggan

S. variabilis D. K. Hughes—Suggan Buggan

S. nervosa J. W. Vickery

S. pubescens R. Br.—Marlo, Buchan, Upper Snowy R. & Suggan Buggan

Panicum fulgidum D. K. Hughes—Maramingo Ck (6 miles NE. of Genoa)

P. effusum R. Br.—Bairnsdale, Buchan, Suggan Buggan, Deddick R.

Paspalidium gracile (R. Br.) D. K. Hughes—Suggan Buggan, Snowy R. gorge & Deddick R. (rain-shadow belt)

Entolasia marginata (R. Br.) D. K. Hughes

†*Oplismenus aemulus* (R. Br.) Kunth

Digitaria brownii (Roem & Schult.) D. K. Hughes—Suggan Buggan

Paspalum distichum L.—Bairnsdale, Orbost, Gabo Is.

Pseudoraphis paradoxa (R. Br.) Pilger—Lake King & Snowy R. near Orbost (? extinct)

Pennisetum compressum R. Br.—Delegate River (near N.S.W. border)

Isachne globosa (Thunb.) Kuntze—Suggan Buggan, Young's Ck near Orbost, Upper Cann R. valley

Spinifex hirsutus Labill.—Lakes Entrance, Coringle, Cape Conran, Gabo Is., Wingan Inlet

Hemarthria uncinata R. Br.—Sperm Whale Head, Lakes Entrance

Imperata cylindrica (L.) Pal. Beauv.
Sorghum leiocladum (Hack.) C. E. Hubbard—Buchan, Ingeegoodbee R.
Bothriochloa ambigua S. T. Blake—Buchan, W Tree, Suggan Buggan, Deddick R.
Dichanthium sericeum (R. Br.) A. Camus—Suggan Buggan & Deddick R. (rain-shadow belt)
Cymbopogon refractus (R. Br.) A. Camus—Orbost district, W Tree, Suggan Buggan & Deddick R., Upper Cann R. valley
Themeda australis (R. Br.) Stapf

CYPERACEAE

Cyperus tenellus L. f.—Marlo, Cann R.
C. brevifolius (Rottb.) Hassk.—Bairnsdale, Suggan Buggan, Tubbut, Combienbar, Genoa
C. lucidus R. Br.
C. rotundus L.—Bairnsdale, Lakes Entrance
C. gunnii Hook f.—Cann River
C. sanguinolentus Vahl—Suggan Buggan, Cabbage-tree Ck, Noorinbee, Genoa
C. concinnus R. Br.—Upper Snowy & Deddick Rivers
C. exaltatus Retz.—Bairnsdale
Scirpus americanus Pers.—Lower Snowy R.
S. nodosus Rottb.—(coastal)
S. validus Vahl—Sperm Whale Head, Bairnsdale, Wuk Wuk
S. polystachyus F. Muell.—Wulgulmerang, Bendoc, Upper Delegate R.
S. maritimus L.—Coringle, Sperm Whale Head
S. fluviatilis (Torr.) A. Gray—Bairnsdale, Newmerella, Brodribb R., Cann R.
S. forsythii Kükenth.—Genoa R. gorge
S. crassiusculus (Hook. f.) Benth.—Cobberas, Wombargo Ra., Upper Delegate R. (subalpine)
S. fluitans L.—Cann R., Lower Delegate R.
S. productus C. B. Clarke—Lake King, Delegate R.
S. antarcticus L.—Cann R., Upper Delegate R.
S. gunnii Boeck.—Mt. Kaye
S. cernuus Vahl
S. aucklandicus (Hook. f.) Boeck.—Cobberas, Nunniong Plateau (alpine)
S. montivagus S. T. Blake—Cobberas (alpine)
S. merrillii (Palla) Kükenth. ex Merrill—Cobberas, Upper Delegate R., Lower Bendoc
S. inundatus (R. Br.) Poir.
S. wakefieldianus S. T. Blake—Cann River district, Reedy Ck
S. stellatus C. B. Clarke—Marlo, Cann R.
S. calocarpus S. T. Blake—Cann R.
S. platycarpus S. T. Blake—Cann R.
Eleocharis sphacelata R. Br.—Mitchell R., Cann R., Wingan Inlet, Upper Delegate R.
E. gracilis R. Br.—Sarsfield, Tonghi Ck, Cann R. district, Ram Head, Delegate R., Genoa
E. acuta R. Br.
Cyathochaeta diandra (R. Br.) Nees—Between Mallacoota & Betka R. mouth
Schoenus tenuissimus Benth.—Mallacoota
S. nitens (R. Br.) Poir.—Sperm Whale Head, Cape Conran, Ram Head
S. imberbis R. Br.—Sperm Whale Head, Betka R. mouth, Mallacoota
S. brevifolius R. Br.—Marlo, Reedy Ck near Cann R.
S. melanostachys R. Br.
S. maschalinus Roem. & Schult.
S. apogon Roem. & Schult.
Tetraria capillaris (F. Muell.) J. M. Black—Reedy Ck near Cann R., Mallacoota, Maramingo Ck (6 miles NE. of Genoa)
Cladium procerum S. T. Blake—Bairnsdale, Orbost district, Lake Curlip
Machaerina articulata (R. Br.) Koyama
M. tetragona (Labill.) Koyama—Newton's Ck near Orbost, Reedy Ck near Cann R., Genoa
M. rubiginosa (Spreng.) Koyama—Snowy R.
M. gunnii (Hook. f.) J. H. Kern—Upper Delegate R.
M. juncea (R. Br.) Koyama
Gahnia melanocarpa R. Br.
G. clarkei G. Benl
G. sieberiana Kunth—Mt. Ellery, Upper Delegate R., Genoa R., Howe Ra.
G. trifida Labill.—Sperm Whale Head, Rigby Is. near Lakes Entrance, Newmerella
G. filum (Labill.) F. Muell.—(coastal)
G. radula (R. Br.) Benth.
Lepidosperma longitudinale Labill.—Sperm Whale Head, Marlo
L. limicola N. A. Wakefield—Reedy Ck near Cann R., Maramingo Ck (6 miles NE. of Genoa)
L. gladiatum Labill.—(coastal)
L. concavum R. Br.—(near-coastal)
L. lineare R. Br.—Nunniong Plateau (alpine)
L. elatius Labill.
L. laterale R. Br.
L. tortuosum F. Muell.—Tonghi Plain, Upper Delegate R. at Bidwell

L. forsythii A. A. Hamilton—Tonghi Plain, Reedy Ck near Cann R., Maramingo Ck (6 miles NE. of Genoa)
L. neesii Kunth—Marlo, Reedy Ck near Cann R., Thurra R., Maramingo Ck
L. urophorum N. A. Wakefield
Gymnoschoenus sphaerocephalus (R. Br.) Hook. f.—Tambo R., near Orbost, Cape Conran, Reedy Ck near Cann R., Maramingo Ck
Caustis flexuosa R. Br.
C. pentandra R. Br.—Sperm Whale Head, Cann River to Tamboon Inlet, Wingan Inlet, Mallacoota
Oreobolus distichus F. Muell.—Cobberas, Nunniong Plateau (alpine)
Chorizandra cymbaria R. Br.—Tonghi Plain, Reedy Ck near Cann R., Mallacoota
Uncinia tenella R. Br.—Arte R., Mt. Ellery, Goonmirk Ra., Mt. Drummer
U. flaccida S. T. Blake—Cobberas (alpine)
Carex capillacea Boott—Cobberas to Wombargo Ra. (alpine)
C. appressa R. Br.
C. raleighii E. Nelmes—Upper Delegate R. at Bidwell (subalpine)
C. curta Gooden.—Cobberas (alpine)
C. inversa R. Br.—Bendoc, Tubbut, Wulgulmerang
C. gaudichaudiana Kunth
C. polyantha F. Muell.
C. longebrachiata Boeck.—Bairnsdale, Tambo R., Cann R.
C. iynx E. Nelmes—Cobberas
C. fascicularis Soland. ex Boott
C. breviculmis R. Br.
C. pumila Thunb.—Marlo, Cape Conran, Mallacoota
C. brownii Tuckerm.—sources of Bemm R.
C. blakei E. Nelmes—Cobberas, Nunniong Plateau (alpine)

PALMAE

Livistona australis (R. Br.) Mart.—Cabbage Tree Ck, Caley's Ck & Lower Brodribb R.

LEMNACEAE

Lemna minor L.—Sperm Whale Head
L. oligorrhiza Kurz—Lakes Entrance, Jarrahmond, Cann River
Wolffia arrhiza (L.) Hork. ex Wimm.—Cann River

RESTIONACEAE

Lepyrodia anarthria F. Muell.—Upper Genoa R., Maramingo Ck (6 miles NE. of Genoa)
L. muelleri Benth.—Cann R. & nearby Reedy Ck, Thurra R.
Restio tetraphyllus Labill.—Sperm Whale Head, Newton's Ck, Cape Conran, Reedy & Dinner Cks near Cann R., Wingan Inlet
R. complanatus R. Br.
R. australis R. Br.—(alps & subalps)
Leptocarpus brownii Hook. f.—Lakes Entrance, Cape Conran, Wingan Inlet
L. tenax (Labill.) R. Br.—Sperm Whale Head, Marlo, Tamboon Inlet, Mt. Drummer, Maramingo Ck (6 miles NE. of Genoa)
Hypolaena fastigiata R. Br.—Sperm Whale Head, Marlo, Mallacoota
Calorophus lateriflorus (R. Br.) F. Muell.

CENTROLEPIDACEAE

Centrolepis polygyna (R. Br.) Hieron—Sperm Whale Head
C. aristata (R. Br.) Roem. & Schult.—Marlo
C. fascicularis Labill.
C. strigosa (R. Br.) Roem. & Schult.

XYRIDACEAE

Xyris operculata Labill.
X. gracilis R. Br.—Reedy Ck near Cann R., Genoa R. (upper tract & gorge), Maramingo Ck (6 miles NE. of Genoa)
X. juncea R. Br.—Maramingo Ck

PHILYDRACEAE

Philydrum lanuginosum Banks ex J. Gaertn.—Bairnsdale district

JUNCACEAE

Luzula campestris, sp. agg.
Juncus maritimus Lam.—(coastal)
J. ingens N. A. Wakefield—McLeod's Morass at Bairnsdale, Brodribb R.
J. pauciflorus R. Br.—Bemm R., Lind & Alfred Nat. Parks, Mallacoota
J. pallidus R. Br.—Sperm Whale Head, Lakes Entrance, Genoa, Mallacoota
J. vaginatus R. Br.—Noorinbee Nth. (Cann R. valley)
J. usitatus L. A. S. Johnson—Snowy R., Genoa R.
J. sarophorus L. A. S. Johnson—Upper Delegate R., Noorinbee Nth.
J. australis Hook. f.—Tubbut-Deddick district
J. gregiflorus L. A. S. Johnson—Bemm R., Combienbar R., Noorinbee Nth., Genoa R.
J. filicaulis Buch.—Gelantipy
J. falcatus E. Mey.—(alps & subalps)
J. planifolius R. Br.
J. caespiticius E. Mey.—Coringle, Lower Snowy R., Ram Head, Gabo Is.

J. bufonius L.
J. revolutus R. Br.—Coringle near mouth of Snowy R.
J. homalocaulis F. Muell.—Mitchell R., Tambo R., Lake Tyers, Mallacoota
J. prismatocarpus R. Br.
J. pusillus Buch.—(alps & subalps)
J. holoschoenus R. Br.
J. fockei Buch.—Wombargo Ra., Upper Snowy R., Goongerah, Lower Bendoc

LILIACEAE

Xanthorrhoea minor R. Br.
X. australis R. Br.
X. resinosa Pers.—(coastal plains eastward from Marlo)
Lomandra filiformis (Thunb.) Britten
L. multiflora (R. Br.) Britten—Upper Cann R. & Mt. Kaye, Mt. Drummer, Upper Genoa R., Genoa Peak, Howe Ra.
L. glauca (R. Br.) Ewart—Murrungowar Rd., Maramingo Ck (6 miles NE. of Genoa)
L. longifolia Labill.
L. confertifolia (F. M. Bailey) A. Fahn—Mt. Kaye, Genoa Peak, Howe Ra.
Chamaescilla corymbosa (R. Br.) F. Muell. ex Benth.—Genoa, Mallacoota
Caesia parviflora R. Br.—Newton's Ck, Coringle, Cann R.
C. vittata R. Br.
Arthropodium milleflorum (DC.) Macbride
A. minus R. Br.—Suggan Buggan, Tubbut (rain-shadow belt)
Dichopogon strictus (R. Br.) J. G. Baker—Bairnsdale
Thysanotus patersonii R. Br.—Sperm Whale Head, Bemm & Cann Rivers
T. tuberosus R. Br.
T. juncifolius (Salisb.) J. H. Willis & A. B. Court—Reedy Ck near Cann R., Mallacoota, Genoa, Maramingo Ck
Bulbine bulbosa (R. Br.) Haw.
B. semibarbata (R. Br.) Haw.—Bairnsdale, Murrungowar, Cann R.
Tricoryne elatior R. Br.
Laxmannia sessiliflora Decaisne—Tonghi Plain & Reedy Ck near Cann R., Betka R. head
L. gracilis R. Br.—Bairnsdale, Wulgulmerang, Maramingo Ck (6 miles NE. of Genoa), Mt. Elizabeth area
Sowerbaea juncea Sm.—(coastal plains eastward from Marlo)
Drymophila cyanocarpa R. Br.—Gelantipy, Upper Delegate R., Bendoc, Goonmirk Ra., Merragunegin Plateau
Dianella tasmanica Hook. f.
D. revoluta R. Br.
D. laevis R. Br.—Sperm Whale Head, Deadcock Ck, W Tree, Murrindal
D. caerulea Sims
Stypandra caespitosa R. Br.—Sperm Whale Head, Cann R., Upper Delegate R., Upper Genoa R., Canni Ck
S. glauca R. Br.
Schelhammera undulata R. Br.
Anguillaria dioica R. Br.—(open grassland around settlements)
Burchardia umbellata R. Br.
†*Geitonoplesium cymosum* (R. Br.) A. Cunn.
†*Eustrephus latifolius* R. Br.
†*Ripogonum album* R. Br.—Lower Brodribb R. & Lockend near Snowy R. mouth, Wingan R., Harrison's Ck in Howe Ra.
†*Smilax australis* R. Br.

HYPOXIDACEAE

Hypoxis hygrometrica Labill.
H. glabella R. Br.—Bairnsdale, Cann R., Upper Delegate R.

IRIDACEAE

Diplarrena moraea Labill.
Libertia pulchella (R. Br.) Spreng.—Mt. Ellery, heads of Delegate R.
L. paniculata (R. Br.) Spreng.—Cabbage Tree Ck, Genoa Gorge & Peak, Mallacoota
Patersonia fragilis (Labill.) Druce—(near-coastal grass-tree plains)
P. longiscapa Sweet—near Orbost
P. glabrata R. Br.
P. sericea R. Br.—Upper Genoa R., Howe Ra., Mallacoota
P. longifolia R. Br.—Confluence of Upper Genoa R. & Yambulla Ck

ORCHIDACEAE

Thelymitra grandiflora R. D. FitzG.—Marlo, between Tonghi & Cann R., Bonang
T. pauciflora R. Br.
T. aristata Lindl.
T. ixioides Swartz
T. media R. Br.—Yalmy R., Bonang, Combienbar
T. chasmogama R. S. Rogers—Orbost
T. irregularis W. H. Nicholls—Reedy Ck near Cann R.
T. retecta H. M. R. Rupp—Upper Delegate R. near Bidwell
T. venosa R. Br.—Upper Delegate R. near Bidwell, Maramingo Ck (6 miles NE. of Genoa)
T. cyanea (Lindl.) Benth.—Upper Delegate R. at Bidwell, Maramingo Ck
T. matthewsii Cheeseman—Cann R. & Genoa districts

T. rubra R. D. FitzG.—Gillingall near Buchan, Cann R.
T. carnea R. Br.—Store Ck near Bairnsdale, Marlo, Genoa
T. flexuosa Endl.—(near-coastal damp grass-tree plains eastward from Newmerella)
Calochilus campestris R. Br.—Orbost, Genoa
C. robertsonii Benth.
C. paludosus R. Br.—Reedy Ck near Cann R.
Diuris punctata Sm.—Bairnsdale, Tambo R. valley, Marlo
D. longifolia R. Br.—Marlo
D. maculata Sm.
D. sulphurea R. Br.
D. pedunculata R. Br.
Orthoceras strictum R. Br.—Marlo
Microtis atrata Lindl.—Mallacoota
M. oblonga R. S. Rogers
M. unifolia (Forst. f.) Reichenb. f.
M. parviflora R. Br.—Orbost & Marlo
Prasophyllum nigricans R. Br.—Sperm Whale Head, McKenzie R., Genoa Ck
P. viride R. D. FitzG.—Mallacoota
P. archeri Hook. f.—Nunniong Plateau & Wulgulmerang district
P. beaugleholei W. H. Nicholls—Upper Delegate R. at Bidwell
P. suttonii R. S. Rogers & R. Rees—Cobberas, Upper Delegate R. at Bidwell (alps & subalps)
P. brevilabre (Lindl.) Hook. f.
P. australe R. Br.—Orbost, Marlo, McKenzie R., Cann R., Thurra R.
P. alpinum R. Br.—Nunniong Plateau, Cobberas (alps)
P. flavum R. Br.—Upper Delegate R. at Bidwell, Bendoc, Mallacoota
P. elatum R. Br.—Genoa R.
P. odoratum R. S. Rogers—Cape Conran, Mallacoota
P. brainei R. S. Rogers—Marlo
P. parviflorum (Rogers) W. H. Nicholls—Bairnsdale, Marlo, Genoa Ck
P. rogersii H. M. R. Rupp—Mallacoota
P. appendiculatum W. H. Nicholls—Tonghi Plain near Cann R., Genoa Ck, Mallacoota
P. hartii R. S. Rogers—Bairnsdale
P. patens R. Br.—Orbost & Marlo, Club Terrace, Combienbar, Genoa R.
P. frenchii F. Muell.—Mallacoota
P. gracile R. S. Rogers—Bairnsdale, Suggan Buggan, Yalmy R.
Caleana major R. Br.
C. minor R. Br.—Sperm Whale Head, Bairnsdale district, Marlo
Spiculaea huntiana (F. Muell.) Schlechter—Nunniong Plateau, Orbost district, Bendoc, Mallacoota
Chiloglottis gunnii Lindl.
C. cornuta Hook. f.—Mt. Ellery, Yalmy R.
C. reflexa (Labill.) Druce
C. trapeziformis R. D. FitzG.—Bairnsdale-Paynesville district, Bruthen, Brodribb R., Cann R.
Acianthus caudatus R. Br.—Sperm Whale Head, Bairnsdale, Newmerella, Marlo, Reedy Ck near Cann R.
A. reniformis (R. Br.) Schlechter
A. exsertus R. Br.
Eriochilus cucullatus (Labill.) Reichenb. f.
Lyperanthus nigricans R. Br.
L. suaveolens R. Br.—Marlo, Noorinbee (Cann R. valley), Howe Ra.
Burnettia cuneata Lindl.—Reedy Ck near Cann R.
Caladenia menziesii R. Br.—Orbost, Cann R.
C. dilatata R. Br.
C. filamentosa R. Br.—Orbost, Cann R.
C. patersonii R. Br.—Marlo
C. pallida Lindl.—Cobberas, Goongerah & Mt. Ellery, Mt. Drummer, Upper Genoa R.
C. clavigera A. Cunn. ex Lindl.—Orbost, Canni Ck
C. tessellata R. D. FitzG.—Marlo
C. reticulata R. D. FitzG.
C. deformis R. Br.—Orbost & Mt. Raymond, Marlo, Genoa R., Mallacoota
C. latifolia R. Br.—Sperm Whale Head, Marlo, Cape Howe
C. alba R. Br.—Combienbar, Upper Genoa R.
C. aurantiaca (R. S. Rogers) H. M. R. Rupp—Marlo, Reedy Ck near Cann R., Genoa
C. carnea R. Br.
C. caerulea R. Br.
C. congesta R. Br.—Wulgulmerang, Bonang & Bendoc, Combienbar
C. lyallii Hook. f.—Wombargo Ra., Mt. Tingaringy (subalpine)
C. angustata Lindl.
C. testacea R. Br.—Wulgulmerang, Bonang, Mallacoota
C. iridescens R. S. Rogers—Sperm Whale Head
Glossodia major R. Br.—Sperm Whale Head, Mt. Kaye, Genoa R.
G. minor R. Br.—(coastal grass-tree plains eastward from Marlo)
Corybas fimbriatus (R. Br.) Reichenb. f.—Sperm Whale Head, Bairnsdale, Marlo, Genoa
C. diemenicus (Lindl.) H. M. R. Rupp—Sperm Whale Head, Bairnsdale, Lakes Entrance, Suggan Buggan, Genoa

C. dilatatus (Rupp & Nicholls) H. M. R. Rupp—Marlo
C. aconitiflorus Salisb.—Newmerella near Orbost, Marlo
C. unguiculatus (R. Br.) Reichenb. f.—Marlo
Cryptostylis hunterana W. H. Nicholls —(near-coastal, damp grass-tree plains eastward from Marlo)
C. erecta R. Br.—Marlo
C. subulata (Labill.) Reichenb. f.—Lake King, Orbost & Marlo, Cape Conran, Cann R.
C. leptochila F. Muell. ex Benth.—Marlo, Cabbage Tree Ck, Murrungowar, Combienbar, Genoa R.
Pterostylis barbata Lindl.—Marlo, Reedy Ck near Cann R., Canni Ck
P. parviflora R. Br.—Sperm Whale Head, Suggan Buggan, Amboyne Ck, Bendoc & Bidwell, Marlo
P. cucullata R. Br.—Serpentine Ck near Yalmy R.
P. falcata R. S. Rogers—Orbost district, Noorinbee (Cann R. valley), Upper Delegate R. at Bidwell, Wulgulmerang
P. alpina R. S. Rogers—Bonang, Brodribb R., Combienbar
P. acuminata R. Br.—Orbost, Brodribb R.
P. grandiflora R. Br.—Marlo district, Mt. Raymond near Orbost
P. revoluta R. Br.—Sperm Whale Head, Suggan Buggan, Deddick R. & Amboyne Ck, Mt. Raymond near Orbost
P. decurva R. S. Rogers—Wulgulmerang & Suggan Buggan, Bendoc, Mt. Buck, Upper Cann R.
P. reflexa R. Br.—Mt. Raymond near Orbost, Cann River district, Mt. Kaye
P. obtusa R. Br.
P. alveata J. R. Garnet—Genoa
P. alata (Labill.) Reichenb. f.—Sperm Whale Head, Orbost
P. concinna R. Br.—Sperm Whale Head, Lakes Entrance, Orbost, Cann R.
P. pedoglossa R. D. FitzG.—Marlo, Mallacoota
P. pedunculata R. Br.
P. nana R. Br.—Marlo, Mallacoota
P. nutans R. Br.
P. curta R. Br.—Sperm Whale Head, Orbost, Cann R., Genoa, Mallacoota
P. baptistii R. D. FitzG.—Cann River, Genoa & Scrubby Cks, Maramingo Ck (6 miles NE. of Genoa)
P. longifolia R. Br.
P. cycnocephala R. D. FitzG.—Nunniong Plateau, Cobberas, Suggan Buggan
P. mutica R. Br.—Sperm Whale Head, Wulgulmerang district, Suggan Buggan
P. pusilla R. S. Rogers—Suggan Buggan, Cann R.
Gastrodia sesamoides R. Br.—Deadcock Ck, Orbost district, Cann R., Combienbar, Bendoc
Spiranthes sinensis (Pers.) Ames—Bendoc, Upper Delegate R. at Bidwell, Snowy R., Brodribb R.
Dendrobium speciosum Sm.—Genoa R. (gorge & upper tracts near N.S.W. border), towards Genoa Peak, Howe Ra.
D. striolatum Reichenb. f.—(rock faces, often granitic)
Dipodium punctatum (Sm.) R. Br.
†*Plectorrhiza tridentata* (Lindl.) A. W. Dockrill
Sarcochilus australis (Lindl.) Reichenb. f.—Mitchell R. gorge tract, Orbost district, Upper Combienbar R., Cann R.
†*S. falcatus* R. Br.—Noorinbee (Cann R. valley), Howe Ra.

DICOTYLEDONS

CASUARINACEAE

Casuarina stricta Dryand.
C. littoralis Salisb.
C. nana Sieber ex Spreng.—junction of Upper Genoa R. & Yambulla Ck (at N.S.W. border)
C. paludosa Sieber ex Spreng.—(near-coastal damp heaths)
C. pusilla E. D. Macklin—Sperm Whale Head

ULMACEAE

†*Trema aspera* (Brongn.) Blume—Mallacoota Inlet (?extinct)

MORACEAE

†*Ficus coronata* Spin.—Mallacoota district (Harrison's & Smellie's Cks)

URTICACEAE

Urtica incisa Poir.
Parietaria debilis Forst. f.
Australina muelleri Wedd.

PROTEACEAE

Persoonia confertiflora Benth.
P. silvatica L. A. S. Johnson—between Bonang & Bendoc, Upper Delegate R. at Bidwell, Goonmirk Ra.
P. juniperina Labill.
P. rigida R. Br.—Dellicknora
P. chamaepeuce Lhotsk. ex Meissn.—Nunniong Plateau, Cobberas, Mt. Stradbroke, Amboyne Ck., Bonang-Bendoc district (subalpine)
?*P. myrtilloides* Sieber ex Schult. & Schult. f.—Yambulla Ck near junction with

Upper Genoa R. (at N.S.W. border)
P. linearis Andr.
P. lucida R. Br.—(near-coastal heaths eastward from Ram Head)
P. levis (Cav.) Domin—(near-coastal heaths eastward from Ram Head)
Conospermum taxifolium Sm.—coast opposite Gabo Is.
Grevillea sp. [aff. G. aquifolium]—Brumby Point on Nunniong Plateau (above Reedy R. gorge), Mt. Stradbroke, Upper Buchan R.
G. rosmarinifolia A. Cunn.—heads of Buchan & Suggan Buggan Rivers
G. australis R. Br.—Nunniong Plateau, Cobberas & near Wulgulmerang (alpine & subalpine)
G. parviflora R. Br.
G. lanigera A. Cunn. ex R. Br.
G. alpina Lindl.—Nowa Nowa
G. chrysophaea F. Muell. ex Meissn.—Sperm Whale Head, Buchan Rd.
G. victoriae F. Muell—Nunniong Plateau, Cobberas, Wombargo Ra., near W Tree, Mt. Tingaringy (alpine & subalpine)
G. miqueliana F. Muell.—Ingeegoodbee R. below Cobberas, Back Ck in Cann R. district
Hakea eriantha R. Br.
H. dactyloides (J. Gaertn.) Cav.—Mt. Kaye (Upper Cann R. area), Mallacoota Inlet & Howe Ra.
H. ulicina R. Br.—Bruthen to Buchan Rd., Cann R., Wingan Inlet, Genoa
H. teretifolia (Salisb.) J. Britt.—Cann R., Genoa, Mallacoota
H. nodosa R. Br.—Sperm Whale Head
H. sericea Schrad. & J. Wendl.
H. lissosperma R. Br.—Nunniong Plateau, Cobberas (alpine)
H. microcarpa R. Br.—(subalpine, also Deddick & Snowy Rivers)
Orites lancifolia F. Muell.—Nunniong Plateau, Mt. Ellery (subalpine)
Telopea oreades F. Muell.—(higher damper forests)
Lomatia fraseri R. Br.—(higher forests)
L. ilicifolia R. Br.
L. myricoides (J. Gaertn.) Domin—(riparian, also montane)
Banksia spinulosa Sm.—(near-coastal forests eastward from Cann R., also Mt. Kaye & Upper Genoa R.)
B. serrata L. f.—(near-coastal heaths & light forests)
B. marginata Cav.
B. canei J. H. Willis—Brumby Point on Nunniong Plateau (above Reedy R.), Wulgulmerang district (subalpine)
B. integrifolia L. f.—(coastline)

SANTALACEAE

Exocarpos nanus Hook. f.—Cobberas, Wulgulmerang district (alps & subalps)
E. strictus R. Br.
E. cupressiformis Labill.
Choretrum pauciflorum A. DC.—Orbost, Yalmy R., Wulgulmerang, Nunniong Plateau, Amboyne Ck near Tubbut
Leptomeria acida R. Br.—Wingan R., Genoa Peak, Wangrabelle, Upper Genoa R.
Omphacomeria acerba (R. Br.) A. DC.—Nunniong Plateau, Wulgulmerang district, Suggan Buggan, Bonang, Wingan R., Upper Genoa R.
Santalum obtusifolium R. Br.—Genoa R. (near Genoa & at confluence with head of Mallacoota Inlet)
Thesium australe R. Br.—Lake King, Gillingal (NW. of Murrindal West Parish), Wulgulmerang

OLACACEAE

Olax stricta R. Br.—swampy heaths in area between Tamboon Inlet, Cape Everard and Dinner Ck (S. of Cann River)

LORANTHACEAE

Muellerina eucalyptoides (DC.) B. A. Barlow
M. celastroides (Sieber ex Schult. & Schult. f.) Van Tiegh.—on coastal *Banksia integrifolia* eastward from Bairnsdale
Amyema miquelii (Lehm. ex Miq.) Van Tiegh.
A. pendulum (Sieber ex Spreng.) Van Tiegh.
A. quandang (Lindl.) Van Tiegh.—on *Acacia* spp. at Buchan, Murrindal and Deddick R.
Dendrophthoë vitellina (F. Muell.) Van Tiegh.—Mallacoota
Notothixos subaureus D. Oliver—Mallacoota, parasitic on *Dendrophthoë* & *Muellerina*)
Korthalsella japonica (Thunb.) Engler—Orbost district, Brodribb R. near junction of Cabbage Tree Ck, Mallacoota (on *Eugenia smithii*)

POLYGONACEAE

Rumex bidens R. Br.—Marlo
R. brownii Campd.
Polygonum plebeium R. Br.—Mitchell R.
P. strigosum R. Br.—Newmerella, Upper Snowy R., Cann R., Wingan Inlet
P. prostratum R. Br.
P. hydropiper L.
P. minus Huds.

P. subsessile R. Br.—Newmerella, Cabbage Tree Ck
P. lapathifolium L.
P. lanigerum R. Br.—Snowy R.
Muehlenbeckia adpressa (Labill.) Meissn.—(coastal sand-hummocks)
M. axillaris (Hook. f.) Walp.—Wulgulmerang, Snowy R.
M. gracillima Meissn.—Cann R., Genoa
M. rhyticarya F. Muell.—Glenaladale Nat. Park, Ensay & Tambo R. above Bruthen
M. diclina (F. Muell.) Druce—Reedy R. gorge, Mt. Stradbroke & Suggan Buggan, Upper Snowy & Deddick Rivers

CHENOPODIACEAE

Rhagodia baccata (Labill.) Moq.—(coastal)
R. hastata R. Br.—Suggan Buggan, Amboyne Ck near Tubbut, Bairnsdale, Orbost
R. nutans R. Br.
Chenopodium trigonon Schult.—Tambo R., near Orbost, Gabo Is.
C. pseudomicrophyllum Aellen—Suggan Buggan (rain-shadow belt)
C. glaucum L.—Coringle, Wingan Inlet, Mallacoota, Gabo Is. (saline flats)
C. carinatum R. Br.—Suggan Buggan & Snowy R. gorge
C. pumilio R. Br.—Upper Snowy R., Sperm Whale Head
Atriplex billardieri (Moq.) Hook. f.—Mallacoota
A. cinerea Poir.—Lakes Entrance
A. muelleri Benth.—Bairnsdale
Enchylaena tomentosa R. Br.—Bairnsdale, Mallacoota
Salsola kali L.—Suggan Buggan & Upper Snowy R., Mallacoota
Suaeda australis (R. Br.) Moq.—(coastal salt-marsh)
Salicornia quinqueflora Bunge ex Ung.-Sternb.—(coast-line)
Hemichroa pentandra R. Br.—Sperm Whale Head (salt-marsh)

AMARANTHACEAE

Alternanthera denticulata R. Br.—(coastal districts)

NYCTAGINACEAE

Boerhaavia diffusa L.—Suggan Buggan (rain-shadow belt)

AIZOACEAE

Tetragonia implexicoma (Miq.) Hook. f.—(coastal)
T. tetragonioides (Pallas) O. Kuntze—Sperm Whale Head, Lakes Entrance, Wingan & Mallacoota Inlets
Disphyma australe (Soland.) J. M. Black—(coastal rocks & salt-marsh)

PORTULACACEAE

Portulaca oleracea L.—Sperm Whale Head & Bairnsdale, Suggan Buggan, Upper Snowy R., Deddick R., Gabo Is.
Calandrinia calyptrata Hook. f.
C. eremaea Ewart—Suggan Buggan, junction of Snowy & Deddick Rivers
Montia australasica (Hook. f.) Pax & Hoffm.
M. fontana L.—Ingeegoodbee (near Cobberas)

CARYOPHYLLACEAE

Gypsophila australis (Schlechtendal) A. Gray—Suggan Buggan, Amboyne Crossing on Deddick R. (rain-shadow belt)
Stellaria pungens Brongn.
S. flaccida Hook.
S. palustris Ehrh. ex Retz.—Sperm Whale Head, Wulgulmerang, Bonang-Bendoc area & Upper Delegate R.
S. multiflora Hook.—Suggan Buggan, Mt. Tingaringy
Sagina apetala L.—Sperm Whale Head & Bairnsdale, Suggan Buggan, Cann R., Genoa R. (gorge & upper tracts)
S. procumbens L.—Cape Conran, Gabo Is.
Spergularia rubra (L.) J. & C. Presl.—Sperm Whale Head, Bairnsdale, Orbost, Cann R.
S. media (L.) C. Presl.—Sperm Whale Head, Lakes Entrance, Mallacoota Inlet (saline flats)
Scleranthus singuliflorus (F. Muell.) Mattf.—Cobberas (alpine)
S. biflorus (Forst. & Forst. f.) Hook. f.
S. diander R. Br.—(chiefly subalpine, from Nunniong Plateau to Goonmirk Ra.)

CERATOPHYLLACEAE

Ceratophyllum demersum L.—Pound Swamp at Bairnsdale, Tonghi Ck

RANUNCULACEAE

Clematis aristata R. Br. ex DC.
C. glycinoides DC.
C. microphylla DC.
Ranunculus trichophyllus Chaix—Little R. at Wulgulmerang
R. millanii F. Muell.—Nunniong Plateau to Cobberas (alpine and subalpine)
R. pimpinellifolius Hook.—Nunniong Plateau, Cobberas, Wombargo Ra. & Wulgulmerang district (alps & subalps)
R. plebeius R. Br. ex DC.

R. lappaceus Sm.
R. rivularis Banks & Soland. ex DC.
R. inundatus R. Br. ex DC.—Bairnsdale, Wulgulmerang, Upper Delegate R.
R. papulentus R. Melville—Wulgulmerang, Newmerella near Orbost
R. collinus R. Br. ex DC.—Nunniong Plateau, Wombargo Ra., Wulgulmerang district (subalpine)
R. sessiliflorus R. Br. ex DC.

MENISPERMACEAE

†*Sarcopetalum harveyanum* F. Muell.

WINTERACEAE

Drimys lanceolata (Poir.) Baill.—(higher mountain forests)
D. xerophila Parment.—Cobberas, Wombargo Ra., Mt. Tingaringy, Delegate R. head, Mt. Ellery (subalpine)

EUPOMATIACEAE

†*Eupomatia laurina* R. Br.

MONIMIACEAE

Hedycarya augustifolia A. Cunn.
Atherosperma moschatum Labill.—Bonang, Goonmirk Ra., Arte R., Mt. Ellery, Mt. Kaye

LAURACEAE

Cassytha glabella R. Br.—Sperm Whale Head, Murrungowar Rd., Marlo, Cann R.
C. pubescens R. Br.
C. melantha R. Br.
C. phaeolasia F. Muell.

PAPAVERACEAE

Papaver aculeatum Thunb.—Deadcock Ck, Suggan Buggan, Deddick R., upper Snowy R. (rain-shadow belt)

CRUCIFERAE

Rorippa islandica (Oeder) Borb.—Bairnsdale, Cann R., Tamboon Inlet (wet places)
Cardamine ? debilis Banks ex DC.
C. laciniata F. Muell.—Suggan Buggan & Willis (at N.S.W. border), Cann R.
C. stylosa DC.—Goonmirk Ra. Combienbar, Mt. Kaye, Wingan Inlet, Howe Ra.
C. distyosperma Hook.—Mt. Ellery, Combienbar Ra., Mt. Elizabeth, W Tree
C. tenuifolia Hook.—Tonghi Ck (near Cann R.)
Drabastrum alpestre (F. Muell.) O. E. Schultz—Suggan Buggan (rain-shadow belt)
Stenopetalum lineare R. Br.—Suggan Buggan (rain-shadow belt)
Lepidium hyssopifolium Desv.
Cakile edentula (Bigelow) Hook.—(seacoast)

DROSERACEAE

Drosera pygmaea DC.—Coringle, Cape Conran, Ram Head & Wingan Inlet, Mallacoota
D. spathulata Labill.—Cann R., Wingan Inlet, Maramingo Ck
D. binata Labill.—Cabbage Tree Ck, Cann R. & Tamboon Inlet, Genoa Ck, Upper Delegate R. at Bidwell
D. auriculata Backh. ex Planch.
D. peltata Sm.—Upper Delegate R. at Bidwell, Upper Genoa R., Cann R.
D. planchonii Hook. f.—Sperm Whale Head

CRASSULACEAE

Crassula sieberiana (Schult. & Schult. f.) Druce
C. macrantha (Hook. f.) Diels
C. peduncularis (Sm.) Meigen—Cape Conran, Cann R.
C. helmsii (Kirk) Berger—Suggan Buggan, Newton's Ck, Coringle, Cann R.
C. pedicellosa (F. Muell.) Ostenf.—Cann R. falls

BAUERACEAE

Bauera rubioides Andr.

PITTOSPORACEAE

Pittosporum undulatum Vent.
P. bicolor Hook.—Bonang, Goonmirk Ra., Mt. Ellery, Mt. Kaye
P. revolutum Dryand.—Genoa R. & Gipsy Point
Marianthus procumbens (Hook.) Benth.
Bursaria spinosa Cav.
Billardiera scandens Sm.
B. longiflora Labill.—Bonang & Bendoc districts, Goonmirk Ra., Wingan Inlet

ROSACEAE

Rubus parvifolius L.
†*R. rosifolius* Sm.
†*R. hillii* F. Muell.
A. ovina A. Cunn.
A. anserinifolia (Forst. & Forst. f.) Druce

MIMOSACEAE

Acacia [species arranged alphabetically]
A. aculeatissima Macbride—(eastward from Brodribb R.)
A. amoena H. Wendl.—Suggan Buggan, Upper Snowy & Deddick Rivers (rain-shadow belt)
A. armata R. Br.—between Bairnsdale & Bullumwaal, Suggan Buggan

A. boormanii Maiden—Emu Egg Ck at head of Buchan R., Wulgulmerang & Suggan Buggan, Snowy R. (in and above gorge tract)

A. botrycephala (Vent.) Desf.

A. buxifolia A. Cunn.—Gelantipy, Suggan Buggan & Wulgulmerang district

A. dealbata Link

A. diffusa Lindl.

A. doratoxylon A. Cunn.—Buchan, Upper Snowy R., Suggan Buggan

A. falciformis DC.

A. floribunda (Vent.) Willd.—Buchan, Snowy, Deddick & Genoa Rivers

A. frigescens J. H. Willis—Result Ck near Bonang, Yalmy R.

A. gunnii Benth.—Nunniong Plateau, Wulgulmerang, Suggan Buggan, Bendoc, Dellicknora, Upper Genoa R.

A. implexa Benth.

A. kybeanensis Maiden & Blakely—Nunniong Plateau (NE. slopes), Wulgulmerang district, Butcher's Ridge

A. lanigera A. Cunn.—Broadbent R. (near Snowy R. gorge tract), Genoa R. (gorge & upper reaches)

A. longifolia (Andr.) Willd.—(near-coastal)

A. lucasii Blakely—Brumby Point at NE. extremity of Nunniong Plateau (above Reedy R. gorge)

A. maidenii F. Muell.—Newmerella near Orbost (?extinct)

A. mearnsii De Wildeman

A. melanoxylon R. Br.

A. mucronata Willd. ex H. Wendl.

A. myrtifolia (Sm.) Willd.

A. obliquinervia M. D. Tindale—(chiefly montane to subalpine)

A. obtusifolia A. Cunn.—Snowy R. gorge, Murrungowar Mtns.

A. oxycedrus Sieber—Sperm Whale Head & Bairnsdale, Bruthen, Marlo

A. paucijuga F. Muell. ex N. A. Wakefield—Wulgulmerang district, Suggan Buggan & Upper Snowy R. valley (in *Eucalyptus albens* forest)

A. pravissima F. Muell.—Wulgulmerang (at Black Mountain), Bete Bolong (?extinct)

A. pugioniformis H. Wendl.—Bruthen-Buchan road, Wingan R.

A. pycnantha Benth.—(along and west of Brodribb R.)

A. rubida A. Cunn.—Murrindal, Wulgulmerang & Suggan Buggan areas

A. siculiformis A. Cunn. ex Benth.—Cobberas, Wombargo Ra., Wulgulmerang & Gelantipy districts (chiefly subalpine)

A. silvestris M. D. Tindale—Nowa Nowa, Murrindal Ck, Wulgulmerang-Gelantipy area, Upper Snowy R., Deddick R. & Amboyne Ck.

A. sophorae (Labill.) R. Br.—Sperm Whale Head, Lakes Entrance, Gabo Is. (coastal)

A. stricta (Andr.) Willd.

A. suaveolens (Sm.) Willd.—(coastal & near-coastal)

A. subporosa F. Muell.—(along & eastward from Bemm R.)

A. ulicifolia (Salisb.) A. B. Court—Sperm Whale Head, Suggan Buggan, Snowy R.

A. verniciflua A. Cunn.—Bairnsdale district, Upper Delegate R., Howe Ra.

A. verticillata (L'Hérit.) Willd.

CAESALPINIACEAE

Cassia aciphylla Benth.— rocky slopes of Tambo, Snowy, Suggan Buggan, Deddick & Genoa Rivers

PAPILIONACEAE

Mirbelia oxyloboides F. Muell.—(montane & subalpine forests)

Oxylobium alpestre F. Muell.—(alps & subalps)

O. arborescens R. Br.—Suggan Buggan, Lind Nat. Park

O. ellipticum (Labill.) R. Br.—(montane & subalpine)

O. ilicifolium (Andr.) Domin—Upper Combienbar, Gipsy Point near Mallacoota, Upper Genoa R.

O. procumbens F. Muell.—Dellicknora, Bonang & Bendoc districts

Gompholobium glabratum Sieber ex DC. —Mt. Kaye & Upper Cann R. valley

G. huegelii Benth.—Sperm Whale Head, Mt. Kaye, Upper Delegate R., Upper Genoa R.

G. latifolium Sm.—Bruthen-Buchan road, Snowy R., between Wingan & Genoa Rivers, Howe Ra.

Sphaerolobium vimineum Sm.—(near-coastal heaths)

Viminaria juncea (Schrad. & J. Wendl.) Hoffmannsegg—Sperm Whale Head, Nowa Nowa district, Brodribb R., Tamboon Inlet

Daviesia wyattiana F. M. Bailey—Mt. Kaye, near Wangrabelle

D. buxifolia Benth.—Upper Genoa R.

D. latifolia R. Br.

D. mimosoides R. Br.

D. ulicifolia Andr.

Pultenaea cunninghamii (Benth.) H. B. Williamson—Mt. Deddick

P. daphnoides J. Wendl.

P. polifolia A. Cunn.—Dellicknora

P. benthamii F. Muell.—Mt. Kaye

P. gunnii Benth.—sources of Bemm R.

P. scabra R. Br.—Bruthen-Buchan road, Brodribb R., Bemm R., Howe Ra. & Mallacoota
P. retusa Sm.
P. capitellata Sieber ex DC.—Upper Delegate R. at Bidwell, near Bendoc
P. paleacea Willd.—near Cape Conran, sources of Brodribb & Bemm Rivers, Upper Genoa R.
P. stricta Sims—Colquhoun State Forest near Nowa Nowa, Howe Ra.
P. linophylla Schrad.—Orbost, Cann R.
P. muelleri Benth.—Cobberas, Wombargo Ra., Wulgulmerang district, Suggan Buggan, Amboyne Ck, Mt. Tingaringy (chiefly subalpine)
P. juniperina Labill.
P. procumbens A. Cunn.—Tubbut
P. largiflorens F. Muell. ex Benth.—Bruthen
P. altissima F. Muell. ex Benth.—Upper Genoa R. (at N.S.W. border)
P. subumbellata Hook.—Nunniong Plateau, Cobberas, Ingeegoodbee R., Bonang, Newton's Ck, McKenzie R.
P. viscosa R. Br. ex Benth.— Bullumwaal
P. mollis Lindl.—Orbost district, Bellbird Ck, Mt. Elizabeth
P. fasciculata Benth.—Cobberas, Upper Delegate R. at Bidwell (alps & subalps)
P. humilis Benth. ex Hook. f.—Bairnsdale, Colquhoun, Bruthen to Buchan, Snowy R.
P. subspicata Benth.—Wulgulmerang, Deddick
P. hispidula R. Br. ex Benth.—Nowa Nowa district, Orbost to Brodribb R., Cann R., Mt. Drummer, Genoa
Aotus ericoides (Vent.) G. Don—(coastal heaths)
Dillwynia juniperina Lodd.—Buchan & Gelantipy districts, Wulgulmerang, Brodribb R.
D. sericea A. Cunn.
D. retorta (J. Wendl.) Druce—Reedy R. gorge, Buchan R., Wulgulmerang, Upper Genoa R.
D. prostrata Blakely—Wulgulmerang district
D. glaberrima Sm.—(near-coastal)
D. capitata J. H. Willis—Mt. Stradbroke near Wulgulmerang
D. cinerascens R. Br.—Bruthen-Buchan Rd.
Platylobium formosum Sm.
Bossiaea foliosa A. Cunn.—Cobberas & Wombargo Ra., Nunniong Plateau (alpine)
B. heterophylla Vent.—Sperm Whale Head & Lake King, Bairnsdale, Genoa to N.S.W. border
B. obcordata (Vent.) Druce—Sperm Whale Head & Bairnsdale, Deadcock Ck, Bullumwaal, Tambo R., Upper Cann R.
B. buxifolia A. Cunn.—Wulgulmerang, Suggan Buggan, Bendoc, Delegate R.
B. prostrata R. Br.
B. cinerea R. Br.—Sperm Whale Head
B. bracteosa F. Muell. ex Benth.—W Tree, Wulgulmerang district, Nunniong Plateau, Reedy R., Bendoc (subalpine)
B. ensata Sieber ex. DC.—(coastal heaths on and east of Betka R.)
Hovea heterophylla A. Cunn. ex Hook. f.
H. longifolia R. Br.—Nunniong Plateau, Cobberas, Wombargo Ra., Mt. Kaye (alps & subalps)
Goodia lotifolia Salisb.
Lotus australis Andr.—Suggan Buggan, Deddick R., Upper Delegate R. at Bidwell
Indigofera australis Willd.
Psoralea adscendens F. Muell.—(montane to subalpine)
P. tenax Lindl.—Deddick R. (between Deddick & Tubbut)
Swainsona oroboides F. Muell. ex Benth. —Suggan Buggan (rain-shadow belt), Wulgulmerang
Desmodium varians (Labill.) Endl.
D. brachypodum A. Gray—Bairnsdale district, Tabberabbera, Suggan Buggan, Upper Snowy R., Deddick R.
Lespedeza juncea (L. f.) Pers.—Suggan Buggan, Bete Bolong, Upper Snowy R., Deddick R.
Kennedia prostrata R. Br.
K. rubicunda (Schneev.) Vent.
Hardenbergia violacea (Schneev.) Stearn
Glycine clandestina J. Wendl.
G. tabacina (Labill.) Benth.—Bairnsdale, Sperm Whale Head, Deadcock Ck, Suggan Buggan

Geraniaceae

Geranium homeanum Turcz.—Mallacoota
G. solanderi R. C. Carolin
G. potentilloides L'Hérit. ex DC.
G. neglectum R. C. Carolin—Upper Delegate R. at Bidwell, Bendoc
G. antrorsum R. C. Carolin—Cobberas, Nunniong Plateau (alpine)
G. sessiliflorum Cav.—Little R. above Wulgulmerang
Erodium crinitum R. C. Carolin—Buchan, Deddick R., Suggan Buggan, Orbost
Pelargonium inodorum Willd.—Reedy R. gorge (against Nunniong Plateau), Mt. Tingaringy, Thurra R.
P. australe Willd.

Oxalidaceae

Oxalis corniculata L.

LINACEAE

Linum marginale A. Cunn. ex Planch.

RUTACEAE

Boronia nana Hook.—Bullumwaal, Wulgulmerang, Reedy Ck, Maramingo Ck
B. algida F. Muell.—Nunniong Plateau, Upper Buchan R. near Wombargo Ra., Cobberas area (alpine)
B. anemonifolia A. Cunn.—Sperm Whale Head, Nunniong Plateau, head of Buchan R., Suggan Buggan, Mt. Kaye, Upper Genoa R.
B. pilosa Labill.—Tabberabbera
B. muelleri (Benth.) E. Cheel—(eastward from Orbost)
B. ledifolia (Vent.) J. Gay—Mt. Elizabeth, near Tambo & Timbarra R. confluence, near W Tree, Snowy R. gorge
B. parviflora Sm.—near Cape Conran, Dinner & Reedy Cks (near Cann R.)
Zieria veronicea (F. Muell.) Benth.—Sperm Whale Head
Z. cytisoides Sm.—near Tabberabbera, Ballantyne Hills above Suggan Buggan, Snowy R. above gorge tract, Howe Ra., Gabo Is., Upper Genoa R.
Z. smithii Andr.
Eriostemon myoporoides DC.—W Tree Ck falls (N. of Buchan)
E. trachyphyllus F. Muell.
Crowea exalata F. Muell.—Nowa Nowa, Tambo R. above Bruthen, W Tree Ck falls, Suggan Buggan
Phebalium phylicifolium F. Muell.—Cobberas (alpine)
P. lamprophyllum (F. Muell.) Benth.—Reedy R. gorge (against Nunniong Plateau), Suggan Buggan, Snowy & Little R. gorges, Amboyne & Gattamurrh Cks, Upper Genoa R.
P. glandulosum Hook.—Upper Snowy R. (in and above gorge tract)
P. squamulosum Vent.
P. ozothamnoides F. Muell.—Wulgulmerang (in gorge country), Mt. Tingaringy (near summit)
P. sp. [*aff P. squameum* (Labill.) Engl.] —Mt. Elizabeth, near Ensay, Wulgulmerang Ck
Asterolasia trymalioides F. Muell.—Cobberas & Playground Top to south (alpine)
A. asteriscophora (F. Muell.) Druce—Upper Genoa R.
Correa alba Andr.—Bairnsdale, Wingan Inlet, Ram Head, Mallacoota, Gabo Is. (coastal)
C. lawrenciana Hook.—(chiefly montane)
C. reflexa (Labill.) Vent.
†*Acronychia laevis* Forst. & Forst. f.—Mitchell R. gorges, Lake King, Lakes Entrance, Bruthen, Brodribb R., Orbost district

TREMANDRACEAE

Tetratheca ciliata Lindl.—Mt. Stradbroke near Suggan Buggan, Mt. Kaye, Upper Genoa R.
T. ericifolia Sm.
T. pilosa Labill.
T. glandulosa Labill.—Murrungowar road (NE. of Orbost), Upper Genoa R.
T. subaphylla Benth.—Mt. Elizabeth area, Murrindal & W Tree, Combienbar, Mt. Kaye, sources of Genoa R.

POLYGALACEAE

Polygala japonica Houtt.—Murrindal West & W Tree, Little R. at Wulgulmerang
Comesperma volubile Labill.
C. ericinum DC.
C. retusum Labill.—Cobberas, Ingeegoodbee R., Wulgulmerang, Upper Delegate R. at Bendoc & Bidwell (subalpine)
C. defoliatum F. Muell.—(Coastal grass-tree plains east from Brodribb R.)
C. calymega Labill.—Sperm Whale Head (heathland)

EUPHORBIACEAE

Phyllanthus gunnii Hook. f.
P. hirtellus F. Muell. ex Muell.-Arg.—(chiefly coastal)
Adriana glabrata Gaudich.—(in and east from Tambo R. valley)
Euphorbia drummondii Boiss.—Suggan Buggan, Deddick R. (rain-shadow belt)
Poranthera microphylla Brongn.
P. corymbosa Brongn.—between Wingan & Genoa Rivers
Micrantheum hexandrum Hook. f.—Bairnsdale-Sarsfield area, W Tree, Nunniong Plateau, Snowy R. gorge, Genoa R. gorge
Pseudanthus ovalifolius F. Muell.—Sperm Whale Head
P. divaricatissimus (Muell.-Arg.) Benth. —Genoa Peak, Howe Ra.
Ricinocarpos pinifolius Desf.—(coastal & near-coastal)
Bertya cunninghamii Planch.—Suggan Buggan area, Upper Snowy R. above McKillop's Bridge
Beyeria leschenaultii (DC.) Baill.—Lake King
B. viscosa (Labill.) Miq.—near Lakes Entrance, Little R. gorge near Wulgulmerang, Suggan Buggan area, Snowy R., Upper Genoa R.
B. lasiocarpa Muell.-Arg.—Bairnsdale-Sarsfield area, Snowy R. gorge, Genoa
Amperea xiphoclada (Sieber ex Spreng.) Druce

CALLITRICHACEAE

Callitriche muelleri Sond.—Snowy R., Bemm R., Mt. Ellery, Cann R., Mt. Drummer

CELASTRACEAE

†*Celastrus subspicatus* Hook.—Bairnsdale, Lakes Entrance, Bruthen, Orbost district

STACKHOUSIACEAE

Stackhousia spathulata Sieber ex Spreng. —near Bairnsdale, Lakes Entrance (coastal dunes)

S. monogyna Labill.

S. intermedia F. M. Bailey—Maramingo Ck (6 miles NE. of Genoa)

SAPINDACEAE

Alectryon subcinereus (A. Gray) Radlk. —junction of Stony Ck & Genoa R. (near gorge tract)

Dodonaea triquetra J. Wendl.—(chiefly east of Snowy R.)

D. rhombifolia N. A. Wakefield—gorge tracts of Snowy & Little Rivers

D. cuneata Sm.

D. viscosa (L.) N. J. Jacq.

D. angustissima DC.—Suggan Buggan, Snowy R. gorge, Deddick R., Gipsy Point & Genoa R.

D. boroniifolia G. Don—Genoa R.

RHAMNACEAE

Pomaderris multiflora Sieber ex Fenzl—Bairnsdale district, Buchan, Snowy R. gorge, Genoa, Upper Genoa R.

P. vacciniifolia Reiss.—Ingeegoodbee district

P. costata N. A. Wakefield—Brodribb R., Upper Genoa R. (at N.S.W. border), Howe Ra.

P. sieberiana N. A. Wakefield—Bullumwaal, Bellbird, Mt. Kaye, Howe Ra.

P. pilifera N. A. Wakefield—Wentworth R., Bruthen-Buchan road, near W Tree

P. discolor (Vent.) Poir.—Tambo R., Brodribb R., Bonang Highway (13 miles beyond Orbost), Tonghi Ck, Wingan Inlet, Mallacoota

P. ligustrina Sieber ex DC.—Monkey Ck near Bruthen, Bruthen, Orbost, mouth of Betka R. near Mallacoota

P. affinis N. A. Wakefield—Bellbird district, Wulgulmerang, Genoa R.

P. feruginea Sieber ex Fenzl—Snowy R., Genoa R.

P. sericea N. A. Wakefield—Upper Genoa R.

P. ledifolia A. Cunn.—Mt. Kaye, Ingeegoodbee R.

P. andromedifolia A. Cunn.—(east of Tambo R.)

P. betulina A. Cunn.—Bairnsdale-Sarsfield area, Bruthen, Suggan Buggan, Deddick R., Genoa R.

P. angustifolia N. A. Wakefield—Mitchell R. gorges, Wulgulmerang district, Ingeegoodbee R., Deddick R., Genoa R.

P. helianthemifolia (Reiss.) N. A. Wakefield—Upper Genoa R.

P. phylicifolia Lodd.—Bairnsdale-Sarsfield area, Wulgulmerang, Suggan Buggan, Deddick R., Upper Genoa R.

P. elachophylla F. Muell.—Wulgulmerang, Ingeegoodbee district, SE. of Bendoc

P. oraria F. Muell. ex Reiss.—(chiefly coastal, also at Buchan, Murrindal & Snowy R. gorge)

P. prunifolia A. Cunn. ex Fenzl—Mitchell R. gorges, Tambo R. near Bruthen, Genoa R. gorge

P. cotoneaster N. A. Wakefield—Upper Genoa R.

P. aspera Sieber ex DC.

P. eriocephala N. A. Wakefield—near Bruthen, Orbost, Genoa, Upper Genoa R.

P. subcapitata N. A. Wakefield—Ensay, Buchan, near W Tree, Suggan Buggan, Deddick R.

P. velutina J. H. Willis—S. slopes of Nunniong Plateau, near W Tree, Suggan Buggan

P. aurea N. A. Wakefield—Buchan, Upper Genoa R.

P. lanigera (Andr.) Sims—(east from Orbost)

P. pauciflora N. A. Wakefield— Reedy R. gorge (against Nunniong Plateau), Suggan Buggan R., Deddick R., Upper Genoa R.

P. pallida N. A. Wakefield—Ingeegoodbee

Spyridium parvifolium (Hook.) F. Muell. —Mt. Drummer, Wingan Inlet

S. cinereum N. A. Wakefield—near Mallacoota aerodrome (coastal heath)

Cryptandra amara Sm.—Nunniong Plateau, Wulgulmerang, Suggan Buggan, Deddick R. & Amboyne Ck, Cann R. valley

Discaria pubescens (Brongn.) Druce—Native Dog Ck near head of Buchan R., Wulgulmerang, Bendoc-Delegate district

VITACEAE

†*Cissus hypoglauca* A. Gray

ELAEOCARPACEAE

Elaeocarpus holopetalus F. Muell.—(chiefly montane)

E. reticulatus Sm.

MALVACEAE

Howittia trilocularis F. Muell.

Gynatrix pulchella (Willd.) Alef.—Mitchell R. gorges, Wentworth R., Tambo R., Buchan, Suggan Buggan, near Orbost

Lawrencia spicata Hook.—Sperm Whale Head, Mallacoota Inlet (in salt-marsh)

STERCULIACEAE

Brachychiton populneus R. Br.—near Nangurner, Mitchell R. gorges, Buchan, Suggan Buggan, Upper Snowy R., Deddick R., Errinundra, Upper Cann R.

Rulingia pannosa R. Br.— Murrindal (near Buchan)

R. prostrata Maiden & Betche—Sperm Whale Head

Commersonia fraseri J. Gay—Mt. Ellery, Errinundra R., Combienbar R., Club Terrace, Genoa R. (incl. gorge tract), Howe Ra.

Lasiopetalum ferrugineum Sm.—Genoa R. gorge

L. dasyphyllum Sieber ex Hook. f.—(east from Tambo R.)

DILLENIACEAE

Hibbertia spathulata N. A. Wakefield—Snowy R. gorge, ?Mt. Elizabeth

H. serpyllifolia R. Br. ex DC.—Mitchell R. gorges, Wulgulmerang district, between Cann & Thurra Rivers, Genoa R. gorge.

H. pedunculata R. Br. ex DC.—Wulgulmerang, Ingeegoodbee district, Upper Snowy R. (incl. gorge), Genoa R. gorge

H. dentata R. Br. ex DC.—(eastward from Orbost)

H. virgata R. Br. ex DC.—Mt. Taylor near Bairnsdale, Nowa Nowa, Orbost, Marlo, Genoa

H. fasciculata R. Br. ex DC.—Sperm Whale Head, Little Ram Head, Mallacoota (coastal heathland)

H. obtusifolia DC.

H. diffusa R. Br. ex DC.—Upper Genoa R., Howe Ra.

H. calycina (DC.) N. A. Wakefield—between Bairnsdale & Deptford

H. stricta (DC.) R. Br. ex F. Muell.—Genoa R.

H. rufa N. A. Wakefield—Reedy Ck (3 miles east of Cann River)

H. acicularis (Labill.) F. Muell.—Sperm Whale Head, Lakes Entrance, near Orbost, Tamboon Inlet, Upper Genoa R. (chiefly coastal)

H. sericea (R. Br. ex DC.) Benth.—Sperm Whale Head, Bruthen-Buchan road, Nowa Nowa

H. aspera DC.—Bruthen district, sources of Brodribb R., Genoa & Mallacoota

H. astrotricha (Sieber ex Spreng.) N. A. Wakefield

EUCRYPHIACEAE

†*Eucryphia moorei* F. Muell.—Howe Ranges

HYPERICACEAE

Hypericum gramineum Forst. f.

H. japonicum Thunb.—Cobberas, Wulgulmerang, Upper Delegate R. at Bidwell, Ram Head & Wingan Inlet (damp shaded ground)

ELATINACEAE

Elatine gratioloides A. Cunn.—Orbost, Genoa R. gorge (on mud)

FRANKENIACEAE

Frankenia pauciflora DC.—Sperm Whale Head (in salt-marsh)

VIOLACEAE

Viola betonicifolia Sm.

V. caleyana G. Don—Dellicknora Ck, Deddick R., Brodribb R., mouth of Genoa R., Delegate R.

V. hederacea Labill.

V. sieberiana Spreng.—Nunniong Plateau, Upper Delegate R. at Bidwell (alps & subalps)

Hybanthus filiformis (DC.) F. Muell.—Mitchell R., Nicholson R. (at Yahoo Ck), sources of Amboyne & Gattamurrh Cks (above Tubbut), Mt. Tingaringy

H. vernonii (F. Muell.) F. Muell.—Marlo, between Little Ram Head & Mallacoota, Genoa R. (coastal heaths)

Hymenanthera dentata R. Br. ex DC.

PASSIFLORACEAE

Passiflora cinnabarina Lindl.—Suggan Buggan, Snowy R. (east of Gelantipy), Orbost & Mt. Buck, Mt. Kaye, Genoa Peak, Genoa R. gorge, Yalmy R.

THYMELAEACEAE

Pimelea curviflora R. Br.—Suggan Buggan district, Upper Genoa R.

P. biflora N. A. Wakefield—Nunniong Plateau, Cobberas (alpine)

P. axiflora F. Muell. ex Meissn.—Goonmirk Ra., Lind Nat Park, Mt. Drummer, Yalmy R.

P. pauciflora R. Br.—Ingeegoodbee R.

P. humilis R. Br.

P. glauca R. Br.—Sperm Whale Head, Bairnsdale, Wulgulmerang & Suggan Buggan, Snowy R.

P. ligustrina Labill.—(montane)

P. alpina F. Muell. ex Meissn.—Nunniong Plateau, Cobberas (alpine)
P. linifolia Sm.—Bruthen, Wulgulmerang, Amboyne Ck, Marlo, Gipsy Point to Mallacoota, Howe Ra.

LYTHRACEAE

Lythrum hyssopifolia L.—near Mt. Drummer
L. salicaria L.—Lake King, Bonang, sources of Delegate R., Snowy R. gorge

MYRTACEAE

†*Eugenia smithii* Poir.
†*Tristania laurina* R. Br.
Angophora floribunda (Sm.) Sweet—Genoa, Mallacoota, Howe Ra.
Eucalyptus [species arranged alphabetically]
E. albens Benth.—Suggan Buggan to Upper Snowy & Deddick River valleys (rain-shadow belt)
E. andreana Naudin—(riparian, eastward from Tambo R.)
E. aromaphloia L. D. Pryor & J. H. Willis—between Cann River & Tamboon Inlet
E. bauerana Schauer—Mitchell R. gorges, between Sperm Whale Head & Nowa Nowa, Upper Genoa R.
E. baxteri (Benth.) Maiden & Blakely—Mt. Kaye, E. of Butcher's Ridge
E. bicostata Maiden et al.
E. blakelyi Maiden—Snowy R. gorge
E. bosistoana F. Muell.—Bairnsdale to Nowa Nowa, Snowy R. gorge, Cann R., Genoa R. (Genoa to Wangrabelle)
E. botryoides Sm.—(near-coastal, from Lake King eastward to Thurra R.)
E. bridgesiana R. T. Baker—Bairnsdale, Nowa Nowa, Bruthen-Buchan Rd., Suggan Buggan, Upper Snowy & Deddick Rivers, near Orbost
E. camphora R. T. Baker—Tongio, Wulgulmerang tableland, Delegate R., Bemm R. (montane to subalpine)
E. cephalocarpa Blakely—(swampy flats between Bairnsdale & Thurra R.)
E. consideniana Maiden—Bairnsdale district, Bruthen-Buchan Rd., near Wulgulmerang, Howe Ra.
E. cypellocarpa L. A. S. Johnson
E. dalrympleana Maiden—Nunniong & Wulgulmerang tablelands, Upper Delegate R., sources of Amboyne Ck & Mt. Tingaringy (usually subalpine)
E. delegatensis R. T. Baker—Nunniong Plateau, Wombargo Ra., Goonmirk Ra., heads of Errinundra & Combienbar Rivers, Mt. Ellery (montane to subalpine)
E. dives Schauer
E. fastigata Deane & Maiden—Bonang-Bendoc district (incl. Delegate R.), Goonmirk Ra., Lind Nat. Park, Mt. Kaye
E. glaucescens Maiden & Blakely—Nunniong Plateau, Mt. Stradbroke above Suggan Buggan, Mt. Wheeler (above Snowy R. at McKillop's Bridge), Mt. Tingaringy (subalpine), Little R. gorge
E. globoidea Blakely
E. goniocalyx F. Muell. (sens. strict.)—Cassilis, Wulgulmerang & Suggan Buggan, Amboyne Ck
E. gummifera (J. Gaertn.) Hochr.—Wingan Inlet, Mallacoota Inlet & Howe Ra., lower Genoa R.
E. kybeanensis Maiden & Cambage—Brumby Point on Nunniong Plateau, Mt. Seldom Seen near Wulgulmerang, Mt. Wheeler above Snowy R. at McKillop's Bridge (subalpine)
E. macrorhyncha F. Muell. ex Benth.—(westward from Brodribb R.)
E. maculata Hook.—between Nowa Nowa & Mt. Tara Ra.
E. maidenii F. Muell.—Lakes Entrance, Nowa Nowa, Cann R., Mallacoota
E. mannifera Mudie—Buchan R. & Nunniong Plateau, Wombargo Ra., Wulgulmerang, Snowy R. gorge, Bonang,
E. melliodora A. Cunn. ex Schauer—(westward from Brodribb R.)
E. muellerana A. W. Howitt
E. nitens (H. Deane & Maiden) Maiden—Bonang to Goonmirk Ra., Mt. Ellery, Mt. Kaye (montane to subalpine)
E. obliqua L'Hérit.
E. ovata Labill.
E. pauciflora Sieber ex Spreng.—(chiefly montane to alpine)
E. perriniana F. Muell. ex Rodway—Nunniong Plateau (near Digger's Holes & Reedy R. gorge)
E. pilularis Sm.—Howe Ra.
E. polyanthemos Schauer—Mitchell R. gorges, Bairnsdale, 10 miles E. of Bruthen, Mt. Kaye, Upper Genoa R.
E. radiata Sieber ex DC.
E. regnans F. Muell.—Mts. Baldhead, Elizabeth & Bindi (NW. portion of East Gippsland), Yalmy R. (E. of Snowy)
E. rubida H. Deane & Maiden—(northern montane tracts)
E. sideroxylon A. Cunn. ex W. Woolls—Bairnsdale district, Bruthen, Lakes Entrance to Nowa Nowa, Gipsy Point near Mallacoota
E. sieberi L. A. S. Johnson
E. smithii R. T. Baker—Wulgulmerang, Genoa Peak, Genoa R. (gorge tract & upper reaches), Howe Ra.
E. stellulata Sieber ex DC.—(subalpine

tablelands from Mt. Baldhead to Cobberas & Upper Delegate R.)

E. tereticornis Sm.—Sperm Whale Head, Bairnsdale, Lakes Entrance, Bruthen

E. viminalis Labill.

Leptospermum laevigatum (J. Gaertn.) F. Muell.—(coastal)

L. myrsinoides Schlechtendal—Sperm Whale Head, Bairnsdale, Bruthen, Nowa Nowa

L. attenuatum Sm.—(near-coastal heaths, eastward from Marlo)

L. brevipes F. Muell.—Bruthen-Buchan Rd., Nunniong Plateau, Mt. Stradbroke near Wulgulmerang, Mt. Tingaringy, Genoa R. & Mallacoota district

L. emarginatum Wendl. f. ex Link—Sarsfield, Nowa Nowa, Genoa R. in and above gorge tract (riparian)

L. phylicoides (A. Cunn. ex Schauer) E. Cheel

L. juniperinum Sm.

L. scoparium Forst. & Forst. f.—(chiefly riparian)

L. obovatum Sweet—Mitchell R. gorges, Bairnsdale & Sarsfield, Nowa Nowa (riparian)

L. micromyrtus Miq.—Cobberas, Mt. Tingaringy (alpine)

L. myrtifolium Sieber ex DC.—(swampy tracts of alps & subalpine tablelands)

L. grandifolium Sm.—(riparian in montane and subalpine tracts)

L. glabrescens N. A. Wakefield—Reedy Ck near Cann R., E. of Butcher's Ridge

L. lanigerum (Ait.) Sm.—(swampy flats in lowlands)

Kunzea parvifolia Schauer—Wulgulmerang district, Snowy R. gorge

K. ambigua (Sm.) Druce—Mt. Kaye, Genoa & Genoa R., Mallacoota, Howe Ra.

Callistemon citrinus (Curt.) Stapf.—Bairnsdale district, Canni Ck (Bruthen-Buchan road), Orbost district (16 miles to west), Thurra R., Genoa, Upper Genoa R.

C. subulatus E. Cheel—Tonghi Ck near Cann R., Wingan Inlet, Genoa R. (gorge & upper branches), Nowa Nowa

C. sieberi DC.—Nunniong Plateau, Cobberas, Ingeegoodbee, Upper Delegate R. at Bidwell, Bendoc (alps & subalps)

C. paludosus F. Muell.—(riparian)

C. pallidus (Bonpl.) DC.—Reedy R. gorge (against Nunniong Plateau), Mt. Stradbroke near Wulgulmerang, Buchan district, Mt. Tingaringy summit (rocky declivities), Mt. Elizabeth

Melaleuca squarrosa Donn ex Sm.—(swampy lowland tracts)

M. armillaris (Soland. ex J. Gaertn.) Sm.—Ram Head & Wingan Inlet, Genoa Peak, Mallacoota, Genoa & Genoa R. gorge, Howe Ra.

M. ericifolia Sm.—(swampy lowland flats & stream-banks)

Baeckea virgata (Forst. & Forst. f.) Andr.—(stream-banks between Bairnsdale & Genoa)

B. linifolia Rudge—Cann R., Mallacoota Inlet, Genoa R., Maramingo Ck (6 miles NE. of Genoa)

B. ramosissima A. Cunn.—Sperm Whale Head, Marlo, Mallacoota

B. gunniana Schauer—Nunniong Plateau, Cobberas (alpine)

B. utilis F. Muell. ex Miq.—(montane to alpine bogs, also Maramingo Ck 6 miles NE. of Genoa)

Calytrix tetragona Labill.

Thryptomene micrantha Hook. f.—Sperm Whale Head

Micromyrtus ciliata (Sm.) Druce—Mt. Stradbroke near Wulgulmerang, Snowy R. gorge

Darwinia camptostylis B.G. Briggs—'East Gippsland' (?vicinity of Cape Howe)

ONAGRACEAE

Epilobium cinereum A. Rich.

E. pallidiflorum Soland. ex A. Cunn.—Combienbar valley

E. billardierianum Ser. ex DC.

E. gunnianum Hausskn.—(montane to alpine)

E. tasmanicum Hausskn.—Rocky Plain N. of Wombargo Ra. (subalpine)

Ludwigia peploides (Kunth.) P. H. Raven—Lake King, Bairnsdale, ½ mile S. of Orbost (aquatic)

HALORAGACEAE

Haloragis elata A. Cunn. ex Fenzl—Wulgulmerang (Boundary Ck)

H. tetragyna (Labill.) Hook. f.

H. teucrioides (DC) Schlechtendal

H. serpyllifolia (Hook. f.) Walp.—Upper Delegate R. at Bidwell

H. depressa (A. Cunn.) Walp.—Ingeegoodbee, Bendoc (subalpine)

H. heterophylla Brongn.—Gelantipy, Wulgulmerang district, Suggan Buggan, Bendoc

H. brownii (Hook. f.) Schindl.—mouth of Snowy R. (?extinct)

H. micrantha (Thunb.) Siebold & Zucc.

H. racemosa Labill.—Ballantyne Hills above Suggan Buggan, Mt. Tingaringy

Myriophyllum pedunculatum Hook. f.—Cobberas, Wombargo Ra., Upper Delegate R. at Bidwell (bogs in alps & subalps)

M. propinquum A. Cunn.—(aquatic)

M. verrucosum Lindl.—Orbost, Deddick R., Genoa R. gorge, Genoa, Buchan, Murrindal, Wulgulmerang (aquatic)

M. elatinoides Gaudich.—Bairnsdale, Orbost district, Genoa R. gorge (aquatic)

Araliaceae

Tieghemopanax sambucifolius (Sieber ex DC.) Viguier

T. multifidus N. A. Wakefield—Bruthen district, Nowa Nowa, Mt. Tara, W Tree, Wulgulmerang district, Mt. Tingaringy, Mt. Buck near Orbost

Astrotricha asperifolia F. Muell. ex Klatt—Sperm Whale Head, Bonang, Wingan Inlet, Mt. Elizabeth

A. ledifolia DC.—Mt. Ellery

A. linearis A. Cunn. ex Benth.—Mitchell R.

A. crassifolia Blakely—Ballantyne Hills above Suggan Buggan, Snowy R. gorge

Umbelliferae

Hydrocotyle verticillata Thunb.—Lake King & Bairnsdale, Suggan Buggan, Newmerella, Marlo, Cann R., Dellicknora Ck (in swamps)

H. laxiflora DC.

H. hirta R. Br. ex A. Rich.

H. sibthorpioides Lam.

H. algida N. A. Wakefield—Wombargo Ra. (alpine)

H. acutiloba (F. Muell.) N. A. Wakefield—Mt. Drummer, Upper Genoa R., Howe Ra.

H. tripartita R. Br. ex. A. Rich.

H. pterocarpa F. Muell.—Lake Tyers, Brodribb R. (east of Orbost), Ram Head, Cann R. & Tonghi Ck

H. geraniifolia F. Muell.—Arte R., Mt. Ellery, Bemm R., Lind Nat. Park, Howe Ra.

H. callicarpa Bunge—Sperm Whale Head, Murrungowar, Combienbar, Cann R., Genoa Ck

Centella cordifolia (Hook f.) Nannfeldt—(damp flats)

Trachymene anisocarpa (Turcz.) B. L. Burtt—Nunniong Plateau, Mt. Stradbroke near Wulgulmerang, Mt. Tingaringy (subalpine)

T. humilis (Hook. f.)Benth.—Cobberas, Wulgulmerang district, Upper Delegate R. at Bidwell (alps & subalps)

Platysace ericoides (Sieber ex DC.) Norman—near mouth of Snowy R.

P. lanceolata (Labill.) Norman

P. heterophylla (Benth.) Norman—Bruthen-Buchan road, Cann R. & Tamboon Inlet

Xanthosia tridentata DC.—Club Terrace, Cann R., Mt. Kaye, Howe Ra.

X. pilosa Rudge—(eastward from Snowy R.)

X. dissecta Hook. f.—Club Terrace, Cann R., Howe Ra.

X. pusilla Bunge—near Cape Conran, Mallacoota, Howe Ra.

Schizeilema fragoseum (F. Muell.) Domin—Cobberas (alpine)

Oschatzia cuneifolia (F. Muell.) Drude—Cobberas, heads of Buchan R., Wombargo Ra. (subalpine)

Oreomyrrhis eriopoda (DC.) Hook. f.—(alps & subalps)

O. brevipes Mathias & Constance—Cobberas (alpine)

O. argentea (Hook. f.) Hook. f.—Nunniong Plateau (subalpine)

O. pulvinifica F. Muell.—Wulgulmerang

Apium prostratum Vent.—(coastal)

A. leptophyllum (Pers.) F. Muell. ex Benth.—Bairnsdale, Marlo, Club Terrace

Sium latifolium L.—Bairnsdale, Lower Nicholson R., near Orbost, Tubbut (marshy terrain)

Sesseli harveyanum F. Muell.—Cobberas, Wombargo Ra. (alpine & sub-alpine)

Lilaeopsis polyantha (Gandoger) Hj. Eichler—Snowy R. (on mud)

Aciphylla glacialis (F. Muell.) Benth.—Cobberas (alpine)

A. simplicifolia (F. Muell.) Benth.—Cobberas, Wombargo Ra., sources of Delegate R., Mt. Tingaringy (alps & subalps)

Daucus glochidiatus (Labill.) Fisch. et al.

Ericaceae

Gaultheria appressa A. W. Hill.—Nunniong Plateau, Wombargo Ra., Cobberas, Upper Delegate R. at Bidwell, Goonmirk Ra., Mt. Ellery, Mt. Tingaringy, Mt. Kaye (subalpine)

Epacridaceae

Styphelia adscendens R. Br.—Genoa

Astroloma humifusum (Cav.) R. Br.

A. pinifolium (R. Br.) Benth.—Sperm Whale Head

Melichrus urceolatus R. Br.—Suggan Buggan, Deddick R. & Amboyne Ck, Dellicknora, Bonang district

Lissanthe strigosa (Sm.) R. Br.—Wombargo Ra., Wulgulmerang & Suggan Buggan, Snowy R. gorge, Cann R., Mt. Kaye

Leucopogon lanceolatus (Sm.) R. Br.—(eastward from Snowy R.)
L. gelidus (F. Muell. ex Benth.) N. A. Wakefield—Nunniong Plateau, Cobberas, Wombargo Ra., Mt. Tingaringy Bonang district, Mt. Ellery (subalpine)
L. parviflorus (Andr.) Lindl.—Lakes Entrance, Marlo, Gabo Is. (coastal)
L. australis R. Br.—Lakes Entrance, Martin's Ck (?30 miles NE. of Orbost)
L. thymifolius Lindl. ex Benth.—Bonang
L. collinus (Labill.) R. Br.—Marlo to Cape Conran, Orbost, Lower Cann R., Genoa R. (near-coastal)
L. pilifer N. A. Wakefield—Nunniong Plateau along sources of Timbarra R. (alpine)
L. pilibundus A. Cunn. ex DC.—Gelantipy, Bonang, Upper Genoa R.
L. virgatus (Labill.) R. Br.—(westward from Brodribb R.)
L. suaveolens Hook. f.—(alps & subalps)
L. montanus (R. Br.) J. H. Willis—Cobberas (alpine)
L. maccraei F. Muell.—Nunniong Plateau, Cobberas, Upper Delegate R. at Bidwell, Goonmirk Ra., Mt. Ellery (subalpine & montane)
L. attenuatus A. Cunn.—Nunniong Plateau, Cobberas, Wulgulmerang district, Mt. Tingaringy, Snowy R., Martin's Ck (30 miles NE. of Orbost), Mt. Kaye, Genoa Peak (chiefly subalpine)
L. ericoides (Sm.) R. Br.—(coastal heaths)
L. riparius N. A. Wakefield—Bete Bolong Ck, Snowy R. east of Butcher's Ridge
L. esquamatus R. Br.—Marlo & Cabbage Tree Ck
L. biflorus R. Br.—(subalpine tablelands)
L. stuartii F. Muell. ex Sond.—Wulgulmerang, Upper Delegate R. at Bidwell, Bonang & Bendoc, Mt. Kaye, Upper Genoa R. & Maramingo Ck
L. juniperinus R. Br.—Mitchell R. gorges, Mt. Nowa Nowa, Murrindal R. (NE. of Buchan)
Acrotriche serrulata (Labill.) R. Br.
A. divaricata R. Br.—Nunniong Plateau (Reedy R. gorge), Mt. Stradbroke & Wulgulmerang district, Mt. Elizabeth
Monotoca elliptica (Sm.) R. Br.—coastal
M. scoparia (Sm.) R. Br.
M. rotundifolia J. H. Willis—Brumby Point at NE. edge of Nunniong Plateau
Brachyloma daphnoides (Sm.) Benth.
Epacris impressa Labill.
E. obtusifolia Sm.—(coastal heaths eastward from Snowy R.)
E. lanuginosa Labill.—Wingan Inlet
E. paludosa R. Br.—(chiefly subalpine)
E. breviflora Stapf—Nunniong Plateau, Cobberas, Ingeegoodbee, Wulgulmerang district, Mt. Tingaringy (subalpine)
E. petrophila Hook. f.—heads of Timbarra R. on Nunniong Plateau
E. ?serpyllifolia R. Br.—Cobberas, Wombargo Ra. (alpine)
E. microphylla R. Br.—(subalpine tracts, also Genoa Peak)
Sprengelia incarnata Sm.—Cape Conran, Lower Bemm R.
Richea continentis B. L. Burtt—Nunniong Plateau & Forlorn Hope Plain, Cobberas (alpine)

MYRSINACEAE

Rapanea howittiana F. Muell. ex Mez—(near-coastal gullies, also Snowy R. gorge)

PRIMULACEAE

Lysimachia salicifolia F. Muell. ex Benth.—near mouth of Snowy R. (?extinct)
Samolus repens (Forst. & Forst. f.) Pers.—(saline flats and cliffs along coast)
S. valerandii L.—Mitchell R. gorges, near Bairnsdale, Tambo R. (between Tongio & Sandy Ck), Suggan Buggan, Snowy R.

OLEACEAE

†*Notelaea longifolia* Vent.
N. ligustrina Vent.—(montane & subalpine forests eastward from Tambo R.)

LOGANIACEAE

Mitrasacme serpyllifolia R. Br.—between the Tambo & Nicholson Rivers, Upper Delegate R. at Bidwell, Cann R., McKenzie R., Maramingo Ck (6 miles NE. of Genoa)
M. pilosa Labill.—Mt. Kaye, Mallacoota
M. polymorpha R. Br.—Orbost, near Alfred Nat. Park, Mallacoota, Howe Ra.
Logania albiflora (Andr.) Druce—W Tree, Mt. Stradbroke (above Suggan Buggan), Mt. Tingaringy, Upper Genoa R., Howe Ra.
L. pusilla R. Br.—mouth of Betka R. (near Mallacoota)

GENTIANACEAE

Gentianella diemensis (Griseb.) J. H. Willis—Cobberas, Nunniong Plateau, Ingeegoodbee, Bonang-Bendoc region, Upper Delegate R. & Goonmirk Ra. (chiefly subalpine)
Sebaea albidiflora F. Muell.—Sperm Whale Head

S. ovata (Labill.) R. Br.—Sperm Whale Head, Wulgulmerang & Suggan Buggan

MENYANTHACEAE

Villarsia exaltata (Soland. ex Sims) G. Don.—Newmerella, Marlo to Cape Conran, Cann R. & Reedy Ck (subaquatic)
V. reniformis R. Br.—Newmerella (subaquatic)
Nymphoides geminata (R. Br.) O. Kuntze —Nunniong Plateau (Bentley's Plain), Rocky Plain toward Cobberas, Wulgulmerang district, Upper Delegate R. at Bidwell (aquatic & subalpine)

APOCYNACEAE

Alyxia buxifolia R. Br.—(Sea-coast from Lakes Entrance eastward)
Parsonsia brownii (J. Britten) Pichon—(chiefly in stream-side forests)

ASCLEPIADACEAE

Tylophora barbata R. Br.
Marsdenia rostrata R. Br.
†*M. flavescens* A. Cunn.—Bairnsdale area, Lakes Entrance, Pipe-clay Ck near Orbost

CONVOLVULACEAE

Convolvulus erubescens Sims—Bairnsdale, Wulgulmerang & Suggan Buggan
Calystegia marginata R. Br.—Sperm Whale Head, Snowy R., Brodribb R. & Cabbage Tree Ck, Mt. Drummer
C. sepium (L.) R. Br.—Mitchell R. gorges, Bairnsdale
C. soldanella (L.) R. Br.—Cape Howe (coastal)
Dichondra repens Forst. & Forst. f.
Wilsonia backhousei Hook. f.—Sperm Whale Head, Mallacoota, Betka R. (in salt-marsh)

CUSCUTACEAE

Cuscuta australis R. Br.—Snowy R. (? extinct)

BORAGINACEAE

Myosotis australis R. Br.
M. suaveolens (R. Br.) Poir.—Snowy R., Upper Bendoc
Omphalolappula concava (F. Muell.) Brand.—Suggan Buggan (rain-shadow belt)
Cynoglossum latifolium R. Br.—Mitchell R. gorges, Bemm R. & Arte R., Lind Nat. Park, Cann R., Mt. Drummer, Howe Ra.
C. suaveolens R. Br.—Wulgulmerang, Mt. Stradbroke & Suggan Buggan, Bruthen, Cann R.
C. australe R. Br.—Mitchell R. gorges, Bairnsdale, Lake Tyers, Suggan Buggan, Snowy R. at McKillop's Bridge, Amboyne Ck, Upper Murrungowar

VERBENACEAE

Verbena officinalis L.—Swift's Ck, Suggan Buggan, Karlo Ck (near Mt. Drummer)

LABIATAE

Plectranthus parviflorus Willd.
Mentha laxiflora Benth.—Reedy R. gorge (against Nunniong Plateau), Wulgulmerang district, Mt. Ellery
M. australis R. Br.—Bairnsdale, Bindi, Wulgulmerang & Suggan Buggan, Snowy R., Delegate R. district, Goonmirk Ra.
M. diemenica Spreng.—Suggan Buggan, Orbost, Mt. Drummer
M. satureioides R. Br.—W Tree to Black Mountain at Wulgulmerang, Nowa Nowa
Lycopus australis R. Br.—Bonang & Delegate R., Newmerella, Howe Ra.
Salvia plebeia R. Br.—Tambo R., Buchan R. & Snowy R. (?extinct), Deddick R.
Prunella vulgaris L.
Scutellaria humilis R. Br.
S. mollis R. Br.—Genoa R. gorge, near Genoa, Mallacoota, Howe Ra.
Prostanthera lasianthos Labill.
P. melissifolia F. Muell.—Howe Ra.
P. rotundifolia R. Br.
P. hirtula F. Muell. ex Benth.—Nowa Nowa district, Buchan-W Tree road, Genoa Peak, Genoa, Howe Ra.
P. denticulata R. Br.—Snowy & Brodribb Rivers, Bruthen-Buchan road, Wairewa (6 miles ENE. of Nowa Nowa), Mt. Elizabeth
P. cuneata Benth.—Cobberas (alpine)
P. phylicifolia F. Muell.—Nunniong Plateau, Wulgulmerang & Mt. Stradbroke, Mt. Tingaringy, Mt. Kaye (subalpine)
P. decussata F. Muell.—N.S.W. border on Monument Ridge (above Upper Amboyne Ck)
P. walteri F. Muell.—W Tree, Mt. Elizabeth, Mt. Ellery, Mt. Kaye (subalpine)
Westringia cremnophila N. A. Wakefield —Snowy R. gorge (E. of 'Tulloch Ard' H.S.)
W. eremicola A. Cunn. ex Benth.—Little R. gorge near Wulgulmerang, Bemm R., Cann R., Genoa R. (gorge tract & upper reaches)
W. glabra R. Br.—Happy Valley (SE. of Nowa Nowa), W Tree Ck falls (14 miles N. of Buchan), Snowy R. gorge, Combienbar, Timbarra R.

Teucrium corymbosum R. Br.—Mt. Stradbroke & Suggan Buggan, Upper Snowy & Little Rivers, Cann River district, Murrungowar
Ajuga australis R. Br.

SOLANACEAE

Solanum aviculare Forst. f.
S. laciniatum Ait.—Genoa R. gorge
S. vescum F. Muell.—Lake King (near mouth of Tambo R.)
S. simile F. Muell.—Blackfellows' Ck (near Gelantipy), Suggan Buggan, Wulgulmerang district (between Little R. falls & Mt. Wheeler), Amboyne Ck, Mt. Tingaringy (chiefly in rain-shadow belt)
†*S. violaceum* R. Br.—Mt. Drummer (?extinct)
S. prinophyllum Dunal
S. pungetium R. Br.—Mitchell R. gorges, Sperm Whale Head, Marlo, Brodribb R., Bemm R. & Combienbar R., near Cape Howe
Nicotiana suaveolens Lehm.—Buchan, Suggan Buggan, Upper Snowy & Deddick Rivers (chiefly in rain-shadow belt)
Anthocercis frondosa (Miers) J. M. Black—Wentworth R.
A. albicans A. Cunn.—Mt. Stradbroke & Suggan Buggan, Snowy R. gorge (rain-shadow belt)

SCROPHULARIACEAE

Mimulus repens R. Br.—Sperm Whale Head, Bairnsdale & Lakes Entrance (saline coastal swamps)
Mazus pumilio R. Br.—(damp flats)
Gratiola peruviana L.
G. pedunculata R. Br.—Tambo R.
G. nana Benth.—Rocky Plain N. of Wombargo Ra.
Glossostigma elatinoides (Benth.) Benth. ex Hook. f.—Suggan Buggan
Limosella australis R. Br.—(permanently wet places)
Veronica perfoliata R. Br.—(stony slopes from Nunniong Plateau eastward to Delegate R.)
V. derwentia Andr.—(montane to subalpine)
V. gracilis R. Br.—(chiefly subalpine)
V. calycina R. Br.
V. plebeia R. Br.—Sperm Whale Head, Mitchell R. gorges, Lakes Entrance, Tambo R., Lind Nat. Park
V. notabilis F. Muell. ex Benth.—(chiefly shaded montane forest)
V. serpyllifolia L.—Ingeegoodbee district (against N.S.W. border)
Euphrasia collina R. Br.—Suggan Buggan & Wulgulmerang, Cann R. to Genoa, Mallacoota, Howe Ra.
E. glacialis Wettst.—Cobberas (alpine)
E. scabra R. Br.—Cobberas (alpine)

BIGNONIACEAE

Pandorea pandorana (Andr.) Steenis

GESNERIACEAE

Fieldia australis A. Cunn.—(tree-fern gullies eastward from Snowy R.)

LENTIBULARIACEAE (aquatic or on mud)

Utricularia dichotoma Labill.—Cobberas, Bruthen-Buchan road, Genoa R. gorge, Maramingo Ck
U. lateriflora R. Br.—Marlo plains, Reedy Ck near Cann R., Mallacoota
U. aurea Lour.—Wulgulmerang & Genoa districts

MYOPORACEAE

Myoporum insulare R. Br.—(coast-line from Sperm Whale Head to Mallacoota)
M. viscosum R. Br.—Lakes Entrance
M. floribundum A. Cunn. ex Benth.—Suggan Buggan R., Upper Snowy R. (above gorge tract) & Deddick R. (rain-shadow belt)

PLANTAGINACEAE

Plantago varia R. Br.
P. debilis R. Br.—Mitchell R. gorges, Wulgulmerang, Orbost, Mt. Drummer, Wingan Inlet.
P. tasmanica Hook. f.—Cobberas, Wulgulmerang (alpine & subalpine)

RUBIACEAE

†*Morinda jasminoides* A. Cunn. ex Hook.
Coprosma quadrifida (Labill.) Robinson
C. hirtella Labill.
C. nivalis W. R. B. Oliver—Nunniong Plateau, Wombargo Ra., Cobberas (alpine)
Nertera reptans (F. Muell.) Benth.—Wulgulmerang, Bendoc, sources of Brodribb R., Bemm R., Errinundra R. & Combienbar R. (montane)
Opercularia aspera J. Gaertn.—mouths of Snowy & Genoa Rivers, Lower Tonghi falls, Marlo, Wingan Inlet
O. hispida Spreng.—Mt. Raymond near Orbost, Wingan Inlet, Cann R., Snowy R. gorge, Genoa R. gorge, Genoa Peak, Howe Ra.
O. varia Hook. f.
O. ovata Hook. f.—Upper Genoa R., Mallacoota
Pomax umbellata Soland. ex J. Gaertn.
Asperula ambleia Shaw & Turrill—Bete Bolong (lower Snowy R.)

A. scoparia Hook. f.—(montane to subalpine areas eastward from Tambo R.)
A. conferta Hook. f.—(chiefly open grasslands)
A. gunnii Hook. f.—Cobberas, Mt. Tingaringy, Upper Delegate R. at Bidwell (alpine & subalpine)
A. pusilla Hook. f.—Cobberas & Mt. Tingaringy (alpine)
A. euryphylla Shaw & Turril—Suggan Buggan
Galium binifolium N. A. Wakefield—mouth of Snowy R., Mt. Drummer, Betka R. near Mallacoota
G. liratum N. A. Wakefield—Boggy Ck (at Nowa Nowa), Wulgulmerang & Suggan Buggan districts, Mt. Ellery, Upper Combienbar, Upper Genoa R.
G. australe DC.—Sperm Whale Head
G. gaudichaudii DC.
G. propinquum A. Cunn.—Mitchell R. gorges, Sperm Whale Head, Lakes Entrance, Suggan Buggan

CAPRIFOLIACEAE

Sambucus gaudichaudiana DC.
S. australasica (Lindl.) Fritsch—Orbost district (lower Snowy & Brodribb Rivers, Cabbage Tree Ck etc.—?extinct)

CUCURBITACEAE

Sicyos angulata L.—Tambo R., Buchan R., Orbost, Cann R. & Noorinbee North, Cape Howe.

CAMPANULACEAE

Wahlenbergia communis R. C. Carolin—Wulgulmerang district & Upper Snowy R. (at McKillop's Bridge)
W. stricta Sweet
W. ceracea T. R. N. Lothian—Nunniong Plateau, Cobberas, Upper Delegate R. (alps & subalps)
W. gloriosa T. R. N. Lothian—Nunniong Plateau, Cobberas (alpine)
W. gymnoclada T. R. N. Lothian—Prince's Highway 13 miles E. of Orbost, Bemm R., Cann R., Mallacoota
W. tadgellii T. R. N. Lothian—Sperm Whale Head, Bairnsdale, Wulgulmerang, Mallacoota
W. quadrifida (R. Br.) A. DC.
W. densifolia T. R. N. Lothian—Nunniong Plain on Nunniong Plateau (subalpine)
W. gracilenta T. R. N. Lothian—Sperm Whale Head, Mt. Stradbroke near Wulgulmerang.

LOBELIACEAE

Lobelia gibbosa Labill.
L. pratioides Benth.
L. alata Labill.—(chiefly coastal)
Pratia purpurascens (R. Br.) F. E. Wimmer—Orbost district, Genoa R. gorge, Mallacoota
P. puberula Benth.—(subalpine tablelands between sources of Buchan & Bemm Rivers)
P. surrepens (Hook. f.) F. E. Wimmer—Cobberas, Wulgulmerang, Upper Delegate R. at Bidwell (alps & subalps)
P. platycalyx (F. Muell.) Benth.—Sperm Whale Head (salt-marsh)
Isotoma axillaris Lindl.—(exposed rocky slopes)
I. fluviatilis (R. Br.) F. Muell. ex Benth.—Mitchell R. gorges, Wombargo Ra., Deddick R., Cann R., Upper Genoa R.

GOODENIACEAE

Velleia paradoxa R. Br.—Wulgulmerang & Suggan Buggan areas, Deddick R. & Amboyne Ck near Tubbut, Bendoc
V. montana Hook. f.—Nunniong Plateau, Cobberas, Ingeegoodbee, Wulgulmerang, Upper Delegate R. at Bidwell, Bendoc (alps & subalps)
Goodenia stelligera R. Br.—Cann R., Thurra R., Wingan R., Genoa Ck
G. ovata Sm.
G. grandiflora Sims—Upper Snowy R. near Mt. Wheeler & at confluence with Suggan Buggan R., Deddick R. (rain-shadow belt)
G. hederacea Sm.—Cobberas, Mts. Stradbroke & Seldom Seen (Wulgulmerang district), Mt. Tingaringy (alpine & subalpine)
G. elongata Labill.—Bruthen, Orbost district, Combienbar R., Cann R. valley, Thurra R.
G. pinnatifida Schlechtendal—Suggan Buggan (rain-shadow belt)
G. paniculata Sm.—Sperm Whale Head, Bairnsdale, Bruthen district, Marlo
G. humilis R. Br.—Bairnsdale, Bruthen, Orbost & Marlo, Cann R., Mallacoota
Coopernookia barbata (R. Br.) R. C. Carolin—W Tree Ck falls (N. of Buchan), Mt. Kaye, Kowat (NE. of Cann River), Genoa district, Howe Ra.
Selliera radicans Cav.—(saline flats along coast)
Scaevola ramosissima (Sm.) Krause—(eastward from Tambo R., & chiefly near-coastal)
S. hookeri (de Vriese) F. Muell. ex Hook. f.—Marlo & Cape Conran
S. aemula R. Br.—Butcher's Ck near W Tree, lower Cann R., Little Ram Head, Genoa R.
S. calendulacea (Andr.) Druce—near

Bairnsdale, Lakes Entrance, Mallacoota Inlet, Gabo Is. (coastal)

S. pallida R. Br.—Bairnsdale, Lake Tyers, Orbost, Cape Howe (coastal)

Dampiera stricta (Sm.) R. Br.

D. purpurea R. Br.—Mt. Seldom Seen near Wulgulmerang, Ballantyne Hills above Suggan Buggan, Snowy R. gorge near W Tree

BRUNONIACEAE

Brunonia australis Sm. ex R. Br.—Mt. Taylor near Bairnsdale, Wairewa (6 miles ENE. of Nowa Nowa), Orbost district, sources of Brodribb R., Cann R.

STYLIDIACEAE

Stylidium graminifolium Swartz

S. lineare Swartz—Rocky Plain N. of Wombargo Ra. (subalpine)

S. laricifolium L. C. Rich.—Wingan Inlet

S. despectum R. Br.—Cann River

COMPOSITAE

Olearia viscosa (Labill.) Benth.—Lake King & Lakes Entrance (coastal)

O. megalophylla (F. Muell.) Benth.—Nunniong Plateau, Cobberas, Wombargo Ra., Ingeegoodbee, Wulgulmerang, Mt. Tingaringy (subalpine)

O. alpicola (F. Muell.) Benth.—Cobberas, Wombargo Ra., Snowy R. gorge, Upper Delegate R. at Bidwell, Bendoc, Mt. Ellery (chiefly subalpine)

O. dentata (Andr.) Moench—Howe Ra. (Harrison's Gully etc.)

O. argophylla (Labill.) Benth.—(chiefly in humid forests)

O. myrsinoides (Labill.) Benth.

O. erubescens (DC.) Dippel—(montane)

O. asterotricha (F. Muell.) Benth.—Brodribb R. & Newton's Ck, Mallacoota

O. lirata (Sims) Hutch.

O. phlogopappa (Labill.) DC.—(chiefly montane to subalpine)

O. rugosa (F. Muell. ex Archer) Hutch. —Orbost district (incl. Mt. Buck), sources of Bemm R.

O. iodochroa (F. Muell.) Benth.—(stony hills from Tambo R. to Mt. Tingaringy)

O. axillaris (DC.) Benth.—Lakes Entrance, Mallacoota (coastal dunes)

O. *floribunda* (Hook. f.) Benth.—Cobberas, Ingeegoodbee, Bendoc (subalpine)

O. algida N. A. Wakefield—Upper Delegate R. at Bidwell (subalpine)

O. ramulosa (Labill.) Benth.—(lowland areas)

O. glandulosa (Labill.) Benth.—(swampy tracts between Mitchell & Cann Rivers, chiefly montane)

O. glutinosa (Lindl.) Benth.—Sperm Whale Head, mouth of Mueller R., Mallacoota (coastal)

Celmisia longifolia Cass.—Nunniong Plateau, Cobberas (alpine)

Vittadinia triloba (Gaudich.) DC.—Sperm Whale Head, Mitchell R. gorges, Bairnsdale, Wulgulmerang & Suggan Buggan, Reedy R., Deddick, Tubbut, Bendoc, Orbost

Erigeron pappochroma Labill.—Nunniong Plateau, Cobberas (alpine)

Lagenophora stipitata (Labill.) Druce

L. gracilis Steetz—Mallacoota Inlet

Solenogyne bellioides Cass.—Wulgulmerang district & Suggan Buggan, Snowy R., Genoa district

Calotis lappulacea Benth.—Glenaladale & Tabberabbera, Mitchell R. gorges, Suggan Buggan, Upper Snowy R., Deddick R. (chiefly in rain-shadow belts), Newmerella & Orbost districts

C. scabiosifolia Sond. & F. Muell.—Cobberas, Wulgulmerang, Upper Snowy R., Delegate R. (chiefly subalpine)

Brachycome decipiens Hook. f.—Nunniong Plateau, Wulgulmerang & Gelantipy, Bendoc, Upper Genoa R. (subalpine tablelands)

B. scapigera (Sieber ex Spreng.) DC.—Nunniong Plateau, Cobberas, Suggan Buggan, Wulgulmerang & Gelantipy districts (alps & subalps)

B. obovata G. L. Davis—Cobberas (alpine)

B. cardiocarpa F. Muell. ex Benth.—Bruthen, Orbost (wet flats)

B. nivalis F. Muell.—Nunniong Plateau, Cobberas (alpine)

B. graminea (Labill.) F. Muell.—(saline coastal flats from Sperm Whale Head to Mallacoota)

B. parvula Hook. f.—Sperm Whale Head, Lakes Entrance (coastal)

B. radicans Steetz—Nunniong Plain on Nunniong Plateau (subalpine)

B. angustifolia A. Cunn. ex DC.—Sperm Whale Head, Orbost district, Cann R. to Mt. Drummer, Karlo Ck, Upper Genoa R., Howe Ra. (near-coastal)

B. multifida DC.—Sperm Whale Head, Mitchell R. gorges, Suggan Buggan, Orbost, Marlo

B. petrophila G. L. Davis—Murrindal R. (near Buchan), Little R. & Boundary Ck (near Wulgulmerang), on cliff-faces

B. diversifolia (R. Graham ex Hook.) Fisch. & C. Mey.—Sperm Whale Head, Timbarra R. near Gillingall, Snowy R.

B. ciliaris (Labill.) Less.—Suggan Buggan (rain-shadow belt)
B. rigidula (DC.) G. L. Davis—Swift's Creek, Cobberas, Suggan Buggan Ra., Monument Ridge at N.S.W. border (above Amboyne Ck), Mt. Tingaringy
B. riparia G. L. Davis—Snowy R. gorge, Genoa R. (gorge tract & upper reaches)
B. aculeata (Labill.) Less.
B. scapiformis DC.—(montane to alpine)
Glossogyne tenuifolia Cass.—Suggan Buggan (rain-shadow belt)
Sigesbeckia orientalis L.
Bidens tripartita L.—Mitchell R. & Bairnsdale, Swift's Creek, Snowy R.
Stuartina muelleri Sond.—Sperm Whale Head, Suggan Buggan, Deddick R.
Gnaphalium purpureum L.
G. involucratum Forst. f.
G. japonicum Thunb.—(chiefly montane)
G. umbricola J. H. Willis—Cobberas, Wombargo Ra., Wulgulmerang, Mt. Tingaringy (subalpine)
G. traversii Hook f.—Snowy R. (? N.S.W.)
G. indutum Hook. f.—Sperm Whale Head
G. luteo-album L.
Ewartia nubigena (F. Muell.) Beauverd—Cobberas (alpine)
Cassinia longifolia R. Br.
C. trinerva N. A. Wakefield—Mt. Ellery
C. aculeata (Labill.) R. Br.
C. uncata A. Cunn. ex DC.—Lake King & Bairnsdale, Lakes Entrance, Snowy R., Tamboon Inlet
Apalochlamys spectabilis (Labill.) J. H. Willis—Sperm Whale Head, Lake King, Lakes Entrance, Cape Everard, Mallacoota, Gabo Is. (coastal)
Helipterum anthemoides (Sieber ex Spreng.) DC.—Nunniong Plateau, Cobberas (playground area), Wulgulmerang & Gelantipy (subalpine)
H. albicans (A. Cunn.) DC.—Reedy R. gorge (against Nunniong Plateau), Wulgulmerang & Suggan Buggan, Ingeegoodbee (subalpine)
H. australe (A. Gray) Druce—Suggan Buggan, Upper Snowy R. & Deddick R. (rain-shadow belt)
Helichrysum baxteri A. Cunn. ex DC.—Orbost to Bell-bird & Ti-tree Cks, Cann R., Thurra R., Genoa R. (gorge & upper tracts), Howe Ra., Timbarra R.
H. apiculatum (Labill.) DC.—Sperm Whale Head, Bairnsdale, Suggan Buggan & Wulgulmerang, Bendoc, Gabo Is.
H. semipapposum (Labill.) DC.
H. scorpioides Labill.
H. rutidolepis DC.—(subalpine tablelands from Cobberas to Goonmirk Ra.)
H. dealbatum Labill.—Bruthen
H. acuminatum DC.—Nunniong Plateau, Cobberas, Wombargo Ra., Mt. Stradbroke near Wulgulmerang, Bonang (alps & subalps)
H. bracteatum (Vent.) Andr.
H. elatum A. Cunn. ex DC.—Orbost district, Ram Head & Wingan Inlet, Howe Ra. (mostly coastal)
H. leucopsidium DC.
H. adnatum (DC.) Benth.—Suggan Buggan & Upper Snowy R. (rain-shadow belt)
H. alpinum N. A. Wakefield—Mt. Kaye (subalpine)
H. paralium (N. T. Burbidge) W. M. Curtis—Sperm Whale Head, Bairnsdale, Lakes Entrance, Wingan Inlet, Mallacoota (coastal)
H. rogersianum J. H. Willis—Nunniong Plateau (Little Reedy R. near Brumby Point)
H. rosmarinifolium (Labill.) Benth.—(montane to subalpine)
H. thyrsoideum (DC.) P. F. Morris & J. H. Willis—(subalpine forests)
H. secundiflorum N. A. Wakefield—Cobberas, Wombargo Ra., Mt. Ellery (alps & subalps)
H. dendroideum N. A. Wakefield
H. conditum N. A. Wakefield—Wulgulmerang & Suggan Buggan, Upper Snowy R., Amboyne Ck, Upper Genoa R.
H. argophyllum (A. Cunn. ex DC.) N. A. Wakefield—Wulgulmerang, Sarsfield, Ram Head & Wingan Inlet, Upper Genoa R. (chiefly coastal)
H. cuneifolium F. Muell. ex Benth.
H. stirlingii F. Muell.—Ingeegoodbee R. near Cobberas
H. obcordatum (DC.) Benth.
H. hookeri, Sond.) Druce—Cobberas (alpine)
Leptorhynchos linearis Less.—Snowy R., Wombat Ck, Cann R., Howe Ra.
L. elongatus DC.—Wulgulmerang, Orbost.
L. tenuifolius F. Muell.—Bairnsdale (grassland)
L. squamatus (Labill.) Less.—Bairnsdale, Cobberas, Wulgulmerang & Suggan Buggan, Bendoc (principally subalpine herbfields)
Rutidosis multiflora (Nees) B. L. Robinson—Sperm Whale Head
Calomeria amaranthoides Vent.—Tambo R. & Monkey Ck near Bruthen, Orbost district, Bemm & Combienbar Rivers, Lind Nat. Park, Mueller R., Genoa R.
Haeckeria ozothamnoides (F. Muell.) F. Muell.—Snowy R. (?extinct)

Podolepis jaceoides (Sims) Voss—Wulgulmerang, Bonang & Bendoc districts
P. robusta (Maiden & Betche) J. H. Willis—Cobberas, Native Dog Ck (alpine)
P. hieracioides F. Muell.—Wombargo Ra., Suggan Buggan Ra., Gelantipy, Goongerah (subalpine)
Angianthus preissianus (Steetz) Benth.—Sperm Whale Head (in salt-marsh)
Calocephalus brownii (Cass.) F. Muell.—Lake King, Lakes Entrance, Cape Conran, Wingan Inlet (coastal)
C. lacteus Less.—Sperm Whale Head (swamp-margins)
Craspedia glauca (Labill.) Spreng.
Cotula coronopifolia L.—Sperm Whale Head, Paynesville & Bairnsdale, Wingan Inlet, Gabo Is. (swampy subsaline coastal tracts)
C. australis (Sieber ex Spreng.) Hook. f.—Sperm Whale Head, Lakes Entrance, Suggan Buggan, Dellicknora Ck (etc.)
C. alpina (Hook. f.) Hook. f.—Gelantipy & Wulgulmerang, Mt. Stradbroke, Wombargo Ra., Cobberas (alps & subalps)
C. reptans (Benth.) Benth.—Sperm Whale Head, Lake Tyers, Ram Head & Wingan Inlet, Cape Conran, Mallacoota, Gabo Is. (chiefly coastal)
C. filicula (Hook. f.) Benth.—subalpine tablelands from Nunniong Plateau to Mt. Ellery & Goonmirk Ra.
Centipeda minima (L.) A. Br. & Aschers.—Wulgulmerang, Lower Bendoc, Cann R., Upper Genoa R.
C. cunninghamii (DC). A. Br. & Aschers.—Mitchell R. gorges, Suggan Buggan, Cann R., Snowy R. gorge
Isoëtopsis graminifolia Turcz.—Suggan Buggan (rain-shadow belt)
Senecio pectinatus DC.—Cobberas (alpine)
S. orarius J. M. Black—Tamboon Inlet (coastal)
S. spathulatus A. Rich.—near Bairnsdale, Lakes Entrance, Marlo, Tamboon Inlet, Mallacoota (coastal sand-hummocks)
S. lautus Forst. f. ex Willd. (sens. lat.)
S. velleioides A. Cunn. ex DC.—(humid forests)
S. vagus F. Muell.—Upper Buchan R., Little R. gorge near Wulgulmerang, Bonang, Brodribb R., Combienbar
S. linearifolius A. Rich.
S. odoratus Hornem.—Sperm Whale Head (coastal)
S. minimus Poir.—(chiefly forestal)
S. biserratus R. O. Belcher—Sperm Whale Head (near-coastal)
S. quadridentatus Labill.
S. gunnii (Hook. f.) R. O. Belcher—Wombargo Ra., Mt. Tingaringy (alps & subalps)
S. glomeratus Desf. ex Poir.
S. hispidulus A. Rich.—Suggan Buggan, Upper Snowy R., Lind Nat. Park, Upper Genoa R., Genoa Peak, Gabo Is.
S. squarrosus A. Rich.—Amboyne Ck near Tubbut, Cape Howe
Arrhenechthites mixta (A. Rich.) R. O. Belcher—sources of Bemm & Delegate Rivers, Bidwell, Mt. Kaye, Genoa Peak, Howe Ra.
Bedfordia salicina (Labill.) DC.—(humid forests)
Cymbonotus preissianus Steetz
C. lawsonianus Gaudich.—Buchan Caves
Microseris scapigera (Forst.) Schult. Bip.—(more open, grassy tracts)
Sonchus megalocarpus (Hook. f.) J. M. Black—Lakes Entrance (coastal dunes)

6

AMPHIBIA OF EAST GIPPSLAND

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Abstract

Nineteen taxa (17 species and two subspecies) of anuran amphibians are recorded from E. Gippsland. The fauna is considered to be predominantly Bassian with cool and warm temperate forms being about equally represented. Distributional data, field observations and general references are provided for each taxon.

Introduction

Moore (1961) and Littlejohn (1967) have discussed the zoogeography of S.E. Australian amphibians in general terms, but the aim of this present paper is to provide a more detailed account, consistent with that of Littlejohn and Martin (1965) for the Bass Strait islands and Littlejohn (1966) for the Victorian Mallee. For present purposes E. Gippsland is defined as that area of Victoria E. of the 148th meridian, and S. of the Continental Divide from that meridian to the border of Victoria and New South Wales.

As indicated by Rawlinson (1966, 1967, and this volume), E. Gippsland falls within the Bassian zoogeographic sub-region and its reptile fauna is largely Bassian. Thus, when examining the amphibians of this area, one may ask whether this fauna is also of a largely Bassian nature.

All specimens examined are contained in the Research Collection, Department of Zoology, University of Melbourne. Mating calls are, in most cases, excellent indicators of species identity and data on these were obtained from road logs of breeding choruses. Only localities additional to those where specimens were obtained are listed in the voice records for each taxon. Where specimens or voice records were obtained from two or more localities within 5 miles radius of a town they have generally been included under the one locality and the term 'area' added. Only specimens and field observations from within the defined area are listed, but literature references apply to a taxon in general. It should be noted that data on calling seasons may be incomplete as no field trips were made into the area in June, July, September and October.

HYLIDAE

Hyla aurea (Lesson)

SPECIMENS: Goongerrah; 11 miles E. of Orbost; Nowa Nowa.

VOICE RECORDS: 8 miles E. of Bendoc; Fairhaven, Mallacoota Inlet; 1 mile N. of Marlo.

LITERATURE RECORDS: Genoa, Gipsy Point, Orbost, Nowa Nowa, 6 miles N. of Lakes Entrance, Corringle Beach (Littlejohn, Martin and Rawlinson 1963).

REMARKS: This species has been heard calling in December and January while floating in open water in dams and swamps. The specimens may be assigned to the subspecies *H. aurea aurea* with the exception of a series from Orbost in which there are indications of *raniformis* characteristics. The situation can be clarified only by further field investigations and analysis. A general account of the complex has been given by Moore (1961) and geographic distribution figured by Littlejohn (1967).

Hyla ewingi Duméril and Bibron

Specimens: 6 miles SW. of Bendoc; 5 miles SW. of Goongerrah; 2 miles NE. of Sardine Creek; 7 and 8 miles SW. of Buchan; Genoa; 2 miles N. of Cann River; 6 miles NW. of Orbost; 6 miles N. of Nowa Nowa; Nowa Nowa area; 2 miles N. of Mallacoota; Bemm River.

Voice Records: Sardine Creek; 12 miles N. of Cann River; 15 miles NE. of Orbost; 10 and 12 miles E. of Orbost; Bellbird Creek; Cabbage Tree; 12 miles W. of Orbost.

Literature Records: These are not cited since in most earlier works no clear distinction was made between *H. ewingi* and *H. verreauxi*.

Remarks: Calls of this species have been heard in February, August, November and December. Males call from emergent or marginal vegetation, at the edges of temporary or permanent ponds, or while floating and supported by emergent vegetation. General references to this species are given by Littlejohn (1966). Martin (1967a) has discussed some aspects of larval ecology.

Hyla jervisiensis Duméril and Bibron

Specimens: The Gap, 6 miles SSE. of Bonang.

Voice Records: None.

Literature Records: Club Terrace By-pass about 12 miles W. of Cann River, Bellbird Creek (Littlejohn, Martin and Rawlinson 1963); 12 miles W. of Cann River, 15 miles N. of Orbost (Martin and Littlejohn 1966).

Remarks: A general account of the morphology, breeding biology, development and distribution of this species is given by Martin and Littlejohn (1966).

Hyla lesueuri Duméril and Bibron

Specimens: Willis; Suggan Buggan; Little River Bridge and McKillop's Bridge on the Wulgulmerang to Bonang Road; Goongerrah; Weeragua area; 3 miles N. of Sardine Creek; Genoa area.

Voice Record: 6 miles SW. of Goongerrah.

Literature Records: Honeysuckle Track near Gelantipy (Brazenor 1947); 22 miles N. of Cann River (Copland 1957).

Remarks: The soft, trilled mating calls of this species have been heard in November and December. Males call from banks and boulders along shallow, rocky streams. General accounts of this species are provided by Moore (1961) and Martin, Littlejohn and Rawlinson (1966). Larval adaptation and ecology are briefly discussed by Martin (1967a).

Hyla peroni (Tschudi)

Specimens: Fairhaven on Mallacoota Inlet.

Voice Records: Nowa Nowa area; 3 miles E. of Brodribb River; 3 miles E. of Lakes Entrance; 6 miles NE. of Lakes Entrance.

Literature Records: Genoa, Gipsy Point, Orbost, 8 miles E. of Lakes Entrance, Marlo (Littlejohn, Martin and Rawlinson 1963).

Remarks: This species has been heard calling from early November to mid-January. Males usually call from elevated positions in the marginal and emergent vegetation of fairly permanent ponds and swamps. The call may be described as a loud, chuckling trill. Moore (1961) has given a general account of this species, and Littlejohn (1967) has briefly discussed its geographical distribution.

Hyla phyllochroa Günther

SPECIMENS: 7 and 9 miles N. of Chandlers Creek; 1 mile N. of Goongerrah; 5 miles SW. of Sardine Creek; 10 miles ENE. of Bellbird Creek; Brodribb River.

VOICE RECORDS: 2 miles NE. of Bonang; 6 miles SW. of Goongerrah; 16 miles E. of Cann River.

LITERATURE RECORDS: 17 miles N. of Cann River, 26 miles N. of Orbost, Genoa, Cabbage Tree Creek (Littlejohn, Martin and Rawlinson 1963).

REMARKS: *Hyla phyllochroa* has been heard calling from November to March along the banks of small streams. The E. Gippsland populations belong to Form A of Littlejohn (1967) which is characterized by having a mating call consisting of one or two long introductory notes followed by a series of shorter notes. Moore (1961) has reviewed the available information on this species, and Copland (1962) recorded it from Victoria for the first time.

Hyla verreauxi Duméril

SPECIMENS: Between the Cobberas; 8 miles SE. of Limestone Creek on the Black Mountain Track; 1 mile N. of Native Dog Plain (about 3 miles SW. of Mt. Cobberas); top of Little River Gorge; Wulgulmerang; 3 miles N. of Gelantipy; 6 miles SW. of Bendoc; 10 miles NE. of Genoa; Genoa; 8 miles SSW. of Buchan; 2 miles N. of Cann River.

VOICE RECORDS: Bonang; 5 miles N. of Chandlers Creek; Goongerrah; 7 miles E. of Cann River; 11 miles WSW. of Genoa; Nowa Nowa; 12 miles WSW. of Orbost; 11 miles E. of Orbost.

LITERATURE RECORDS: These cannot be used since in most earlier works no distinction was made between *H. verreauxi* and *H. ewingi*.

REMARKS: This species has been heard calling in August and from November to February at the borders of temporary pools, swamps and dams. Litlejohn (1963, 1965) has described adult morphology, distribution and mating call structure of this species. Martin (1965) has commented on the similarity of the larvae of *H. verreauxi* and *H. ewingi*. The specimens from the Mt. Cobberas area may be assigned to the subspecies *H. verreauxi alpina* Fry (see comment by Littlejohn, 1967, p. 155).

LEPTODACTYLIDAE

Crinia haswelli Fletcher

SPECIMENS: Genoa; 15 miles NE. of Orbost; 3 miles SW. of Nowa Nowa.

VOICE RECORDS: Stony Creek, 6 miles NW. of Nowa Nowa; 11 miles E. of Orbost; 12 miles WSW. of Orbost; 6 miles NW. of Bemm River.

LITERATURE RECORDS: 5 miles E. of Cann River (Moore 1961); 8 miles NE. of Genoa, 8 miles E. of Genoa, 2 miles NW. of Mallacoota, Cann River, 8 miles S. of Buchan, 6 miles N. of Nowa Nowa, Cabbage Tree, Bemm River, Corringle Beach, Marlo (Littlejohn, Martin and Rawlinson 1963).

REMARKS: The mating call of this species may be described as a short, bell-like 'ank'. Males have been heard calling in August and from November to March from the banks of, or while floating in, temporary or permanent ponds, dams and swamps. Two mated pairs (inguinal amplexus) were seen floating in a small pond during early March. Moore (1961) has given a general account of this species and Martin (1967b) has briefly described and figured the larva.

Crinia signifera Girard

SPECIMENS: 30 miles E. of Benambra on Mt. Cobberas track; Mt. Cobberas; Nunyong Tableland; Wulgulmerang; 1 mile N. of Goongerrah; Weeragua area; 8 miles NW. of Genoa; 8 miles NE. of Genoa; Buchan area; 7 and 8 miles SSW. of Buchan; 12 miles W. of Cann River; 4 miles N. of Nowa Nowa; 2 miles S. of Cabbage Tree; Bemm River.

VOICE RECORDS: 6 and 8 miles E. of Bendoc; Bonang area; 10 miles N. of Chandlers Creek; Goongerrah area; Chandlers Creek area; Sardine Creek; Genoa area; Gipsy Point; Mallacoota area; 15 miles NE. of Orbost; 2 miles N. of Cann River; 6 miles N. of Nowa Nowa; 12 miles E. of Bruthen; Nowa Nowa area; Orbost area; 12 miles E. of Orbost; 12 miles WSW. of Orbost; Cabbage Tree area; 2 miles W. of Bellbird Creek; 6 miles NW. of Bemm River; Corringle Beach; Marlo; Lakes Entrance area.

LITERATURE RECORDS: Little River between Buchan and New South Wales border (Brazenor 1947); Youngs Creek, 9 miles N. of Orbost (Moore 1961).

REMARKS: This common species has been heard calling from November to March and in May and August. Most lentic sites (temporary and permanent) are utilized for breeding and males usually call from sheltered positions at the edges of the breeding sites. Litlejohn (1966) has listed recent references to this species. Martin (1967b) refers to some aspects of larval ecology.

Crinia victoriana Boulenger

SPECIMENS: 6 miles SW. of Bendoc; 1 mile N. of Goongerrah; Genoa.

VOICE RECORDS: 6 miles S. of Bonang; 4 miles N. of Goongerrah; Cann River area; 7 miles E. of Cann River; 14 miles E. of Orbost.

LITERATURE RECORDS: Bonang, 3 miles S. of Bonang, Gelantipy, 13 miles N. of Buchan, 3 miles S. of Buchan, Cann River, 12 miles N. of Nowa Nowa, 6 miles N. of Nowa Nowa, Cabbage Tree Creek (Littlejohn and Martin 1964).

REMARKS: Mating calls of *Crinia victoriana* have been heard in February and March. Littlejohn and Martin (1964) provide a detailed account of the general biology, morphology and distribution of this species.

Heleioporus australiacus Shaw

SPECIMENS: None.

VOICE RECORDS: None.

LITERATURE RECORD: 200 and 300 yards S. of the Victoria-New South Wales border (about 29 miles N. of Cann River) (Littlejohn and Martin 1967).

REMARKS: The available information on this striking, but rather secretive, species has been summarized by Littlejohn and Martin (1967).

Limnodynastes dorsalis (Gray)

SPECIMENS: Nunyong Tableland, 28 miles NE. of Ensay; 10 miles NE. of Genoa; Fairhaven, Mallacoota Inlet; 6 miles S. of Buchan; Cann River area; 15 miles NE. of Orbost; 6 miles N. of Nowa Nowa; 6 miles NW. of Orbost; Nowa Nowa; Orbost; 10 and 11 miles E. of Orbost; Bemm River area; 6 miles N. of Lakes Entrance; 5 miles E. of Lakes Entrance.

VOICE RECORDS: 6 and 8 miles E. of Bendoc; Bonang area; Goongerrah; 6 miles N. of Chandlers Creek; 3 miles S. of Buchan; 1 mile S. of Genoa; Gipsy Point; Mallacoota area; Bete Bolong; 12 miles WSW. of Orbost; Corringle Beach area; 4 miles NE. of Lakes Entrance; 6 miles E. of Lakes Entrance.

LITERATURE RECORDS: Little River (Brazenor 1947); 5 miles E. of Cann River (Moore 1961).

REMARKS: This species has been heard calling in August and from November to March. Numerous egg masses were seen in early March, 1961, following very heavy rains. Males usually call while floating, concealed by overhanging and emergent vegetation, and a wide range of temporary and permanent still water habitats is utilized for breeding. The material may be assigned to the subspecies *insularis* Parker with the exception of the specimen from the Nunyong Tableland which is of the subspecies *dumerili* Peters (A. A. Martin, pers. comm.). Littlejohn (1966) has provided general references to the species and geographic distributions of the subspecies is figured by Littlejohn (1967). Martin (1967a) has discussed oviposition patterns within the *L. dorsalis* complex.

Limnodynastes peroni (Duméril and Bibron)

SPECIMENS: 10 miles N. of Chandlers Creek; 7 miles S. of Gelantipy; Goongerrah; 7 miles S. of Buchan; Club Terrace By-pass; 2 miles N. of Cann River; Nowa Nowa; Bemm River; 6 miles N. of Lakes Entrance.

VOICE RECORDS: 6 and 8 miles E. of Bendoc; Bonang; 10 miles N. of Chandlers Creek; Chandlers Creek area; 6 miles SW. of Goongerrah; 10 miles NE. of Genoa; 3 and 4 miles E. of Genoa; Gipsy Point; 5 miles SW. of Sardine Creek; 15 and 16 miles NE. of Orbost; 12 miles E. of Bruthen; 3 miles E. of Brodribb River; Lakes Entrance area.

LITERATURE RECORDS: None.

REMARKS: Mating calls of this species have been heard from November to March. Males call from concealed sites while floating in fairly permanent still water. General accounts have been given by Moore (1961) and Littlejohn (1963). The larva has been described by Martin (1965) and some aspects of oviposition are discussed by Martin (1967a).

Limnodynastes tasmaniensis Günther

SPECIMENS: Wulgulmerang.

VOICE RECORDS: 6 and 8 miles E. of Bendoc; 1 mile S. of Bonang; Lakes Entrance area.

LITERATURE RECORDS: None.

REMARKS: Calls were heard in March, November and December and were all of the Southern Call Race (*sensu* Littlejohn, 1966). Males of this species call while floating in open positions in temporary and permanent still-water habitats. *L. tasmaniensis* appears to be restricted to the extreme northern and western borders of E. Gippsland (see distribution map in Littlejohn, 1967). Other recent references are given by Littlejohn (1966).

Mixophyes fasciolatus Günther

SPECIMENS: 10 miles N. of Chandlers Creek (just S. of the border between Victoria and New South Wales).

VOICE RECORDS: None.

LITERATURE RECORDS: None.

REMARKS: This species is recorded from Victoria for the first time. The specimens were collected on the evening of 6:XII:65 and were calling from the banks and boulders along a shallow rocky stream. The mating call is a short grating trill (Form B of Littlejohn, 1967). Moore (1961) has provided a general account of the species complex, and Martin (1967a) has described some aspects of larval morphology and ecology.

Pseudophryne dendyi Lucas

SPECIMENS: Mt. Cobberas area; Limestone Creek, 25 miles E. of Benambra; Willis; Nunyong Tableland, 28 miles NE. of Ensay; Wulgulmerang area; 6 miles SW. of Bendoc; 2 miles S. of Bonang; 8 miles S. of Gelantipy; 13 miles N. of Buchan; 1 mile N. of Weeragua; 12 miles N. of Cann River; 3 miles S. of Buchan; 7 and 8 miles S. of Buchan; 2 miles W. of Club Terrace; Cann River area; 10 miles W. of Genoa; 2 miles N. of Mallacoota.

VOICE RECORDS: Little River Bridge area, Wulgulmerang-Bonang Road.

LITERATURE RECORDS: Honeysuckle Track, near Gelantipy (Brazenor, 1947, as *P. bibroni*); Bonang and 15 miles N. of Orbost (Moore 1961).

REMARKS: This species has been heard calling from mid-February to late April. An amplexed pair was taken on 20:II:63 and eggs were seen on 16:IV:65. Males call from shallow burrows in low, swampy areas which will later flood with winter rains. Eggs are laid in these burrows and initial development is terrestrial. A general account of the species is given by Moore (1961) and a distribution map is figured by Littlejohn (1967). The mating call is similar to that of *P. semimarmorata* and may be described as a short, grating 'ark'.

Pseudophryne semimarmorata Lucas

SPECIMENS: Bete Bolong; 1 mile S. of Newmerella; 4 miles SW. of Nowa Nowa; 5 miles E. of Lakes Entrance; 1 mile N. of Corringle Beach; Marlo.

VOICE RECORDS: None.

LITERATURE RECORDS: None.

REMARKS: This species has similar breeding habits to those of *P. dendyi* and has been heard calling in March and May. Specimens from 1 and 6 miles N. of Nowa Nowa appear to be intermediate between *P. dendyi* and *P. semimarmorata* and indicative of limited hybridization. Littlejohn (1963) has given a brief general account of the species; Martin (1965; 1967a) has described and figured the larva. Littlejohn (1967) has presented a map of distribution and commented on the hybridization between the taxa.

Uperoleia marmorata Gray

SPECIMENS: 3 miles SW. of Nowa Nowa.

VOICE RECORD: 3 miles E. of Lakes Entrance.

LITERATURE RECORD: 2 miles N. of Cann River (Littlejohn, Martin and Rawlinson 1963).

REMARKS: Mating calls of this species were heard on 7:XII: 63 and the call may be described as a long, rasping 'squelch'. Males were calling from the litter at the edge of a small, fairly permanent pool. A general description of the species has been given by Moore (1961) who prefers to recognize only one species within the genus. On our present information it seems more reasonable to follow Parker (1940) and to recognize this entity as distinct from the *U. rugosa* (Andersson) complex which appears to contain at least two sibling species (Forms A and B of Littlejohn, 1967).

Discussion and Summary

Nineteen taxa (17 species and two subspecies) are known to occur in E. Gippsland (Table 1). Of these, 12 (or 63%) are probably restricted to the Bassian subregion (*sensu* Spencer 1896; see discussion by Littlejohn 1967, and Rawlinson, this volume), seven with typically southern (cool temperate) distributions and five with

TABLE 1

Zoogeographic Analysis of the Amphibian Fauna of E. Gippsland

Species	*Exclusive Bassian*		Eyrean	Uncertain
	Southern	Eastern		
HYLIDAE				
Hyla aurea		x		
H. ewingi	x			
H. jervisiensis		x		
H. lesueuri				x
H. peroni				x
H. phyllochroa				x
H. verreauxi verreauxi				x
H. v. alpina	x			
LEPTODACTYLIDAE				
Crinia haswelli		x		
C. signifera				x
C. victoriana	x			
Heleioporus australiacus		x		
Limnodynastes dorsalis dumerili			x	
L. d. insularis	x			
L. peroni				x
*L. tasmaniensis**	x			
*Mixophyes fasciolatus***		x		
Pseudophryne dendyi	x			
P. semimarmorata	x			
TOTAL	7	5	1	6

* Southern call race of Littlejohn (1966).

** Form B of Littlejohn (1967).

typically eastern (warm temperate) distributions (Table 1). Of the remainder, six are either wide-ranging through the Bassian and Torresian sub-regions, or their northern limits are not known, or they belong in sibling species complexes for which little field data are available. Accordingly, these are classed as of uncertain zoogeographic status for the present purposes (Table 1), although some may actually belong in the Eastern Bassian Component.

The last taxon to be considered, *Limnodynastes dorsalis dumerili*, ranges mainly through areas on the inland slopes of the Dividing Range and adjacent plains and may be considered as a marginal Eyrean form (i.e. typical of the Eyrean sub-region of Spencer 1896); it appears to penetrate into E. Gippsland by way of the Monaro Plains (see map in Littlejohn 1967). Two other marginal Eyrean taxa also occur in the southern Monaro area of New South Wales. We have records of *Neobatrachus pictus* Peters from 7 miles N. and 9 miles SW. of Bombala, and of *Uperoleia rugosa* (Form B of Littlejohn 1967, i.e. characterized by a long, unpulsed mating call) from two miles N. of Bombala, and from 4 miles NE. and 3 miles W. of Delegate. These two species may subsequently be found in the apparently suitable drier tract of E. Gippsland along the border between the Snowy and Cann Rivers.

In summary, we may conclude that the anuran amphibian fauna of E. Gippsland is composed largely of Bassian taxa with eastern warm temperate and southern cool temperate forms being about equally represented. Only one Eyrean taxon has been found in the defined area, and with two others which occur close by in southern New South Wales may constitute an Eyrean or Monaro intrusive component. The balance of the fauna is made up of wide-ranging forms (Bassian and Torresian), or of taxa for which more field data are required.

Acknowledgments

The assistance of R. S. Frankenberg, Patricia G. Littlejohn, A. A. Martin, J. A. Owen and family, P. A. Rawlinson and D. S. Woodruff in collecting specimens and providing field data is greatly appreciated.

Field work was carried out during periods of support by research grants from the Australian Research Grants Committee, the Nuffield Foundation and the University of Melbourne.

A. A. Martin read the manuscript.

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7

THE REPTILES OF EAST GIPPSLAND

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Introduction

Gippsland is included in Spencer's (1896) Bassian zoogeographic subregion and its reptile fauna has been described as typically Bassian (Rawlinson 1966, 1967). However the data and principles on which this conclusion was based were not given in these earlier papers and the present account of the reptiles of East Gippsland provides an opportunity to correct the situation.

The Bassian subregion (*sensu* Serventy & Whittell 1951) lies within the temperate zone, and temperatures in the area are generally lower than those prevailing elsewhere in Australia. This factor is a most important one for reptiles, as internal thermoregulation is the only major physiological homeostatic capacity which they lack (Bartholomew 1958). Temperatures decrease with an increase in latitude and altitude; thus the coldest zones in the Bassian subregion are the more southerly areas and the mountain tops. For this reason, the Bassian subregion can be divided into three thermal zones, each of which appears to have a characteristic reptile fauna (Rawlinson unpublished):

1. Warm temperate zone: Coastal plains of E. New South Wales and E. Victoria; inland margins of the Eastern Highlands; and the coastal plains of SW. Victoria and SE. South Australia.
2. Cool temperate zone: Eastern Highlands in New South Wales and Victoria, including the Southern Uplands; N. and E. Tasmania.
3. Cold temperate zone: Alpine areas in E. Victoria and SE. New South Wales; highlands and S. and W. areas of Tasmania.


Gorge of the Little River
(*A. W. Howitt, 1876.*)

East Gippsland (defined as that area of Victoria E. of 148° longitude and S. of the New South Wales border) lies mainly in the warm temperate zone, but the cool temperate zone is represented in the Australian Alps and Coastal Ranges above 2000 ft. Thus distributional data for the reptiles of East Gippsland could reveal some species which are restricted to the lower elevations (warm temperate) and others which are restricted to the higher elevations (cool temperate).

The most extensive form of vegetation in East Gippsland is wet sclerophyll forest (Wood and Williams 1960), although other forms of vegetation (especially dry sclerophyll forest) are well represented in some areas. In wet sclerophyll forest, the tree stratum (consisting of all sclerophyllous trees) is dense and continuous, frequently with a discontinuous understorey of shade tolerant trees; the shrub stratum (consisting of mesomorphic and sclerophyllous shrubs) is also dense and continuous; and the herbaceous stratum is poorly developed, although ferns may be common. Thus climax wet sclerophyll forest prevents solar radiation penetrating to the ground, except where there are natural clearings such as along rivers and creeks, around swamps, and in rocky areas. Such dense forests are largely inaccessible to heliothermic (basking) reptiles which use solar radiation for maintenance of elevated body temperatures. Thigmothermic (non-basking) reptiles can invade these forests, but, as East Gippsland is in the temperate zone where temperatures are low, this imposes a severe thermal stress and necessitates lowered thermal preferences.

Reptilian Fauna

Twenty-four of the twenty-nine species known to occur in East Gippsland are heliotherms and they are most abundant in areas where solar radiation can penetrate to the ground, e.g. the margins of rivers, creeks and swamps; rocky outcrops; burnt or cleared areas; and areas where the vegetation is open. Of the five thigmothermic species, one (*Denisonia nigrescens*) is nocturnal and the other four are fossorial litter inhabitants (*Leiolopisma delicata* and *L. mustelinum* in forest clearings at the lower altitudes, *Hemiergis decresiensis* in open vegetation such as woodland or shrubland, and *Siaphos maccoyi* in wet sclerophyll forest at the higher altitudes). It is interesting to note that only one species (*S. maccoyi*) actually lives in the wet sclerophyll forest, and that the thigmothermic families *Gekkonidae* and *Typhlopidae*, which are well represented in the warmer parts of Australia, are absent.

Recent work has suggested that there are four reptilan species complexes in SE. Australia (Rawlinson unpublished). Three of these complexes have been studied in detail, but the other is incompletely known. In spite of this, the evidence to hand shows that the *Egernia cunninghami*, *Denisonia superba* and *Notechis scutatus* complexes are represented in East Gippsland by only one taxon and the *Sphenomorphus quoyi* complex by two taxa. The complexes are discussed below under the relevant species headings.

In the following locality records, data for each species are presented under four headings:

1. Specimens examined: includes the localities of all specimens examined in the collections of the University of Melbourne Zoology Department (MUZD) and the National Museum of Victoria (NMV).
2. Specimens observed: includes the author's field records of all reptiles seen but not collected.
3. Literature records: includes all known literature records for East Gippsland.
4. Distribution: gives the general distribution of all East Gippsland reptiles based on the author's collecting in SE. Australia and reliable literature records.

CHELONIA

CHELYIDAE

Chelodina longicollis (Shaw)

SPECIMENS EXAMINED: (MUZD) Nil. (NMV) Nil.
SPECIMENS OBSERVED: Orbost; Lake Tyers.
LITERATURE RECORDS: Southern rivers of Gippsland (McCoy 1878).

DISTRIBUTION: Coastally from Tropic of Capricorn southwards to Sale region, Victoria. Also occurs throughout the Murray-Darling River system, extending from this system into SW. Victoria and SE. South Australia via the Grampians.

SQUAMATA

LACERTILIA

AGAMIDAE

Amphibolurus diemensis (Gray)

SPECIMENS EXAMINED: (MUZD) Native Dog Plain, 4½ miles SW. of Mt. Cobberas; ½ mile E. of Native Dog Plain. (NMV) Nil.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Nil.

DISTRIBUTION: Tasmania, Flinders Is., highlands of E. Victoria and SE. New South Wales to the Blue Mountains.

Amphibolurus muricatus (Shaw)

SPECIMENS EXAMINED: (MUZD) Wallaby Rocks, Wulgulmerang; Buchan Caves; Mallacoota. (NMV) Snowy R.; Lakes Entrance.

SPECIMENS OBSERVED: 15 miles W. of Orbost.

LITERATURE RECORDS: Nil.

DISTRIBUTION: SE. Australia from about the Queensland border southward along the coastal and inland margins of the Eastern Highlands. Also occurs in SE. South Australia and SW. Australia.

Physignathus lesueuri (Gray)

SPECIMENS EXAMINED: (MUZD) Suggan Buggan R., Suggan Buggan; 5½ miles N. of Gelantipy; Scrubby Ck, N. of Buchan. (NMV) Upper reaches of Buchan R.; Junction of the Snowy and Broadbent Rivers; Orbost.

LITERATURE RECORDS: Upper reaches of the Buchan R. (McCoy 1878); Buchan and Snowy Rivers (Lucas and Frost 1894); Gippsland (Worrell 1963).

DISTRIBUTION: E. coast of Australia from the Cape York Peninsula (Qld.) to Walhalla in SE. Victoria. The Gippsland form has been described as a subspecies, *P. lesueuri howitti* (McCoy 1878).

SCINCIDAE

Egernia cunninghami (Gray)

Egernia cunninghami complex: This complex is poorly known, and at present it appears that there are three taxa, all of which are restricted to SE. Australia. The first taxon occurs in the E. coastal region of New South Wales, the second taxon on the W. margin of the Eastern Highlands in New South Wales and along the Murray R. into South Australia, and the third taxon on the margins of the Eastern Highlands in S. New South Wales and Victoria. The latter taxon is the only one occurring in East Gippsland.

SPECIMENS EXAMINED: (MUZD) 7 miles S. of Suggan Buggan. (NMV) Rockbank, 7 miles N. of Wulgulmerang; Gelantipy.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Nil.

DISTRIBUTION: E. coast of Australia from SE. Queensland to E. Gippsland, also occurs along the inland margin of the Eastern Highlands into N. Victoria and SE. South Australia, penetrating into SW. Victoria through the Kilmore Gap.

Egernia saxatilis Cogger

Specimens Examined: (MUZD) 7 miles S. of Suggan Buggan; 2 miles N. of Cann River; 8 miles SE. of Sardine Creek. (NMV) Gelantipy; Wingan; Mt. Wills.

Specimens Observed: Bemm R., 8 miles ENE. of Bell Bird Creek.

Literature Records: Croajingolong (Lucas & Frost 1894 as *Egernia striolata*).

Distribution: Rocky outcrops along the Eastern Highland from SE. Queensland to the Grampians in W. Victoria. The Gippsland form fits Cogger's (1960) subspecies *E. saxatilis intermedia.*

Egernia whitei (Lacepede)

Specimens Examined: (MUZD) Native Dog Plain, 4½ miles SW. of Mt. Cobberas. (NMV) Buchan.

Specimens Observed: Nil.

Literature Records: Nil.

Distribution: Coastal regions and highlands of SE. Australia. Also occurs in Tasmania, the Bass Strait islands, SE. South Australia and SW. Australia.

Emoia spenceri Lucas & Frost

Specimens Examined: (MUZD) Mt. Delegate; Delegate R., 5½ miles SW. of Bendoc. (NMV) Nil.

Specimens Observed: Nil.

Literature Records: Croajingolong (Lucas & Frost 1894).

Distribution: Highlands of SE. New South Wales and E. Victoria from Mt. Franklin (A.C.T.) to Lake Mountain (Vic.). Also occurs in the Otway Ranges, SW. Victoria.

Hemiergis decresiensis (Fitzinger)

Specimens Examined: (MUZD) Nil. (NMV) Honeysuckle Track, Gelantipy; Buchan.

Specimens Observed: Nil.

Literature Records: Honeysuckle Track, Gelantipy (Brazenor 1947).

Distribution: E. New South Wales, E. Gippsland, N. Victoria, SE. South Australia and Kangaroo Is.

Leiolopisma delicata (De Vis)

Specimens Examined: (MUZD) 1½ miles N. of Goongerrah; Goongerrah Ck, Goongerrah; 12 miles N. of Cann River; Dead Calf Ck, 5 miles S. of Goongerrah; 8 miles E. of Genoa; 2 miles N. of Cann River; 2 miles N. of Mallacoota; 12 miles E. of Cann River; 15 miles NNE. of Orbost; 8½ miles ENE. of Orbost; Newtons Ck, 11½ miles W. of Cabbage Tree Creek; 2½ miles S. of Nowa Nowa; 5 miles SSW. of Nowa Nowa; Bemm River. (NMV) Cann River; Orbost.

Specimens Observed: Nil.

Literature Records: Nil.

Distribution: E. coast of Australia from SE. Queensland southward to just E. of Melbourne. Also occurs in NE. Tasmania.

Leiolopisma entrecasteauxi (Duméril & Bibron)

Specimens Examined: (MUZD) Square Flat, 2 miles NW. of Mt. Wombargo; 2 miles N. of Wulgulmerang. (NMV) Honeysuckle Track, Gelantipy.

Specimens Observed: Nil.

Literature Records: Honeysuckle Track, Gelantipy (Brazenor 1947).

Distribution: Southward along the Eastern Highlands from Mt. Barrington (N.S.W.), extending onto the coastal plains in S. Victoria and SE. South Australia. Also occurs on the Bass Strait islands and in Tasmania where it is restricted to the N. and E. coastal plains.

Leiolopisma guichenoti (Duméril & Bibron)

Specimens Examined: (MUZD) Suggan Buggan; 7 miles S. of Suggan Buggan; 2 miles N. of Wulgulmerang; 5½ miles N. of Gelantipy; 5½ miles N. of Goongerrah; Goanna Ck, 1 mile N. of Goongerrah; 12 miles N. of Cann River; East Buchan; 8 miles E. of Genoa; 2 miles N. of Cann River; Poddys Ck, 8 miles NE. of Bell Bird Ck; 15 miles N. of Orbost; Bemm River. (NMV) Rockbank, 7 miles N. of Wulgulmerang; Buchan; Bruthen; Cann River; Orbost.

Specimens Observed: 4½ miles N. of Goongerrah.

Literature Records: Nil.

Distribution: SE. and SW. Australia generally, from the coast inland to about the 20 inch isohyet. On the E. coast, *L. guichenoti* does not extend much further north than Brisbane, and it is absent from the highlands in SE. New South Wales and Victoria.

Leiolopisma mustelinum (O'Shaughnessy)

Specimens Examined: (MUZD) Little R., 5 miles NNE. of Wulgulmerang; 2 miles N. of Wulgulmerang; 3 miles N. of Goongerrah; Goanna Ck, 1 mile N. of Goongerrah; Martins Ck, 2½ miles N. of Sardine Creek; Buchan Caves; 2 miles N. of Cann River; 12 miles W. of Cann River; 2 miles N. of Mallacoota; Fairhaven, Mallacoota; 7 miles ENE. of Bell Bird Creek; 9 miles ENE. of Orbost; 8½ miles E. of Orbost. (NMV) Jungle at head of Basin Ck.

Specimens Observed: 4½ miles N. of Goongerrah.

Literature Records: Croajingolong (Lucas & Frost 1894).

Distribution: E. coastal Australia from Mt. Barrington (N.S.W.) to just E. of Melbourne.

Leiolopisma trilineatum (Gray)

Specimens Examined: (MUZD) Suggan Buggan; Square Flat, 2 miles NW. of Mt. Wombargo; 5 miles N. of Bentleys Plains; Mabel Cave, East Buchan. (NMV) Nil.

Specimens Observed: Nil.

Literature Records: Nil.

Distribution: Coastal and inland margins of the Eastern Highlands in SE. Australia from about the Warrumbungle Ranges south. Also occurs in SW. Australia, SE. South Australia, the Bass Strait islands and the coastal regions of N. and E. Tasmania.

Leiolopisma weeksae? Kinghorn

Specimens Examined: (MUZD) 2 miles N. of Wulgulmerang; 5 miles W. of Goongerrah. (NMV) Honeysuckle Track, Gelantipy.

Specimens Observed: Nil.

Literature Records: Honeysuckle Track, Gelantipy (Brazenor 1947 as *Leiolopisma metallicum*).

DISTRIBUTION: Inland margin of the Eastern Highlands in SE. New South Wales from Jenolan southwards into Victoria, crossing the watershed in W. central Victoria and penetrating to the Otway Ranges.

Siaphos maccoyi Lucas & Frost

SPECIMENS EXAMINED: (MUZD) Ridge above Nunyong Plains; Little R., 5 miles NNE. of Wulgulmerang; 2 miles N. of Wulgulmerang; Bonang; 3 miles S. of Bonang; 5½ miles N. of Goongerrah; 4½ miles N. of Goongerrah; Goanna Ck, 1 mile N. of Goongerrah. (NMV) Rockbank, 7 miles N. of Wulgulmerang; Gelantipy; 5 miles S. of Tullochard near Gelantipy; Jungle at head of Basin Ck.; Wingan; Lakes Entrance.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Croajingolong (Lucas & Frost 1894); Honeysuckle Track, Gelantipy (Brazenor 1947).

DISTRIBUTION: Highlands of SE. New South Wales and E. Gippsland from Talbingo (N.S.W.) south, then extending into W. Gippsland and SW. Victoria along the forested coastal plains and southern slopes of the Eastern Highlands.

Sphenomorphus tympanum (Lonnberg & Andersson)

Sphenomorphus quoyi complex: Four morphologically distinct forms of the Water Skink, *Sphenomorphus quoyi*, occur in SE. Australia, only one of which is not restricted to the Bassian subregion. Three forms are represented by widespread and largely allopatric populations, and the other by disjunct alpine populations included within the ranges of these three. Only two of the forms (*S. quoyi* and *S. tympanum*, cool temperate form, see below) have not been found in sympatry and, as there are no indications of hybridization in sympatric populations (Rawlinson, unpublished), it appears that all forms have reached species status. A detailed account of speciation in the *S. quoyi* complex is planned, but since two of the taxa occur in East Gippsland, a summary of the nomenclatorial conclusions seems desirable at this stage.

Quoy and Gaimard (1824) described and figured a skink collected at Neutral Bay, Sydney. They did not name it as a new species, however, simply referring to it as the 'Scinque à flancs noirs'. Duméril and Bibron (1839) re-described the specimen and named it as a new species, *Lygosoma quoyi*. Following the most recent revision of lygosomid skinks (Mittleman, 1952) this species is currently known as *Sphenomorphus quoyi*. Lonnberg and Andersson (1913) described and named a new skink, *Lygosoma tympanum*, 'said to have been collected in the neighbourhood of Melbourne'. Subsequently, Kinghorn (1932) described a new skink from Mt. Kosciusko which he named *Hinulia quoyi kosciuskoi*. Loveridge (1934) placed *tympanum* in the genus *Sphenomorphus* and made it a subspecies of *S. quoyi*. At the same time he synonymized *kosciuskoi* with *tympanum*.

Collections made at type localities, comparisons of topotypes to original descriptions, examination of the original figure of *S. quoyi* (Quoy and Gaimard, 1824, Pl. 42, fig. 1) and the type series of *S. quoyi kosciuskoi* (Australian Museum) have enabled positive identifications to be made of *quoyi*, *tympanum* and *kosciuskoi*. These taxa represent three of the four morphological forms of the *S. quoyi* complex. The fourth taxon is closely related to *tympanum*, but is apparently undescribed. It has previously been referred to as *Sphenomorphus sp. nov.* (Rawlinson, 1967). As my unpublished results indicate that Loveridge (1934) was wrong in synonymizing *tympanum* and *kosciuskoi*, the two taxa are re-established in this paper. Also, as my evidence indicates that all taxa have reached species status, *tympanum* is restored to specific rank. This explains the use of the name *Sphenomorphus tympanum* in this paper.

In East Gippsland, *S. tympanum* and the closely related undescribed form occur. Locality data for each taxon must therefore be separated, so *S. tympanum* (*sensu lato*) has been divided into two groups. The first group, described as the 'Cool Temperate Form', is the typical form of *S. tympanum*. The second group, described as the 'Warm Temperate Form', is the undescribed (and probably specifically distinct) form of *S. tympanum*.

COOL TEMPERATE FORM

SPECIMENS EXAMINED: (MUZD) Quambat Plain, 7½ miles NNE. of Mt. Cobberas; Head of Indi R., 1½ miles E. of Quambat Plain; Native Dog Plain, 4½ miles SW. of Mt. Cobberas; Ridge above Nunyong Plains; Back R. bridge, 5 miles N. of Bentleys Plains; 2 miles N. of Wulgulmerang; 5½ miles N. of Gelantipy; Mt. Delegate; 2½ miles SW. of Bendoc; 11 miles SW. of Bendoc; 8½ miles N. of Goongerrah; 7½ miles N. of Goongerrah; 5½ miles N. of Goongerrah; 4½ miles N. of Goongerrah; 5 miles W. of Goongerrah. (NMV) Wombargo Ck, 7 miles SW. of Suggan Buggan; Rockbank, Wombargo Ck, 7 miles N. of Wulgulmerang; Honeysuckle Track, Gelantipy.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Wombargo Ck 3000', 5 miles W. of Suggan Buggan (Brazenor 1947).

DISTRIBUTION: Highlands of SE. New South Wales and Victoria, from the Brindabella Ranges (A.C.T.) southward. Occurs throughout the Victorian coastal plains from Stradbroke (W. Gippsland) W. to about Mt. Richmond (SW. Victoria).

WARM TEMPERATE FORM

SPECIMENS EXAMINED: (MUZD) Native Dog Plain, 4½ miles SW. of Mt. Cobberas; Ingeegoodbee R., 5 miles N. of Suggan Buggan; 4 miles S. of Willis; Suggan Buggan R., Suggan Buggan; Tullochard Gorge, 3 miles W. of Butchers Ridge on Snowy R.; 5 miles N. of Goongerrah; 1 mile N. of Goongerrah; Goongerrah Ck, Goongerrah; 5 miles N. of Chandlers Creek; Junction of Murrindal R. and Butchers Ck, 12 miles NNE. of Buchan; Martins Ck, 10 miles SSE. of Goongerrah; Martins Ck, 2½ miles N. of Sardine Creek; Buchan R., 1 mile W. of Murrindal; Murrindal R., ½ mile E. of Murrindal; ½ mile E. of Genoa; Wild Dog Ck, 4 miles S. of Sardine Creek; 2 miles N. of Cann River; Wingan R., 10½ miles ESE. of Genoa; 8 miles SE. of Sardine Creek; 15 miles NNE. of Orbost; 9 miles ENE. of Orbost; Poddys Ck, 8 miles E. of Bell Bird Creek; 10 miles E. of Orbost; 8½ miles E. of Orbost; Bell Bird Creek; 2 miles N. of Bemm River; Bemm River. (NMV) Rockbank, Wombargo Ck, 7 miles N. of Wulgulmerang; Junction of Snowy and Broadbent Rivers; Snowy R. Gorge; Mouth of Betka R., Mallacoota; 10 miles S. of Buchan; Cann River; Orbost; Wingan Inlet.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Honeysuckle Track, near Gelantipy (Brazenor 1947).

DISTRIBUTION: Highlands of NE. New South Wales, coastal and inland margins of the Eastern Highlands in SE. New South Wales and NE. and SE. Victoria. Also occurs on the Fleurieu Peninsula, South Australia.

Tiliqua casuarinae (Duméril & Bibron)

SPECIMENS EXAMINED: (MUZD) Genoa; Gipsy Point. (NMV) Nil.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Nil.

DISTRIBUTION: Highlands and coastal regions of E. New South Wales and E. Gippsland from about Gosford (N.S.W.) southward to Mt. Hotham (Vic.). Also occurs in Tasmania where it is widespread.

Tiliqua nigrolutea (Quoy & Gaimard)

SPECIMENS EXAMINED: (MUZD) Suggan Buggan; 7 miles SW. of Bonang. (NMV) Gelantipy.

SPECIMENS OBSERVED: Tongio West.

LITERATURE RECORDS: Nil.

DISTRIBUTION: Highlands of E. New South Wales and Victoria from about Gosford (N.S.W.) southward, extending onto the coastal plains in W. Gippsland, SW. Victoria and SE. South Australia. Also occurs in Tasmania and the Bass Strait islands, where it is widely distributed.

Tiliqua scincoides (Shaw)

SPECIMENS EXAMINED: (MUZD) Nil. (NMV) Nil.

SPECIMENS OBSERVED: Mallacoota; 16 miles WNW. of Orbost; 14½ miles WNW. of Orbost; 4 miles WSW. of Orbost.

LITERATURE RECORDS: Nil.

DISTRIBUTION: Occurs throughout N. and E. Australia inside the 20 inch isohyet, missing only the highland regions of SE. New South Wales and E. Victoria (including the S. Gippsland Highlands). *T. scincoides* does not occur any farther W. than Adelaide (S.A.). Mitchell (1955) described the N. Australian form as a subspecies, *T. scincoides intermedia.*

VARANIDAE

Varanus varius (Shaw)

SPECIMENS EXAMINED: (MUZD) Nil. (NMV) Junction of Snowy and Broadbent Rivers.

SPECIMENS OBSERVED: 15 miles N. of Orbost; 17 miles WSW. of Cann River; 13 miles E. of Bruthen; 12½ miles E. of Nowa Nowa; 3 miles E. of Cabbage Tree Creek.

LITERATURE RECORDS: Cabbage Tree Creek; Andersons Inlet (Lucas & Frost 1894).

DISTRIBUTION: Throughout E. Australia inside the 20 inch isohyet, extending as far W. as Kangaroo Is. (S.A.). Does not occur in the highlands of SE. New South Wales and Victoria, or in W. Gippsland and SW. Victoria.

OPHIDIA

BOIDAE

Morelia argus argus (Linnaeus)

SPECIMENS EXAMINED: (MUZD) Nil. (NMV) 5 miles SSW. of Mallacoota.

SPECIMENS OBSERVED: Nil.

LITERATURE RECORDS: Worrell (1963) records the species from Eden, New South Wales.

DISTRIBUTION: Coastal region of SE. Australia from Coffs Harbour (N.S.W.) to Mallacoota (Vic.). A subspecies, *M. argus variegata* is widely distributed over the rest of Australia except for S. Victoria and Tasmania.

Elapidae

Demansia textilis (Duméril & Bibron)

Specimens Examined: (MUZD) Murrindal. (NMV) Gelantipy; Genoa.

Specimens Observed: 1 mile N. of Buchan; 3 miles S. of Genoa.

Literature Records: Nil.

Distribution: In E. Australia, *D. textilis* is common on the dry inland plains. The species also penetrates down the E. coast into E. Gippsland and through the Kilmore Gap into the SW. Victorian plains, but it is absent from the highlands of SE. New South Wales and Victoria (including the S. Gippsland Highlands). The range of the species to the W. is unknown, as the taxonomic status of W. populations of *Demansia* has not been determined.

Denisonia coronoides (Günther)

Specimens Examined: (MUZD) Nil. (NMV) Orbost.

Specimens Observed: Native Dog Plain, 4½ miles SW. of Mt. Cobberas; Morass Ck, 5 miles S. of Mt. Misery.

Literature Records: Nil.

Distribution: Coastal and highland regions of SE. Australia from Sydney southwards to Mt. Gambier in South Australia. Also occurs on the Bass Strait islands and Tasmania.

Denisonia nigrescens (Günther)

Specimens Examined: (MUZD) 8½ miles ENE. of Orbost; 5 miles SSW. of Nowa Nowa. (NMV) Orbost.

Specimens Observed: Wulgulmerang area; 5 miles S. of Buchan.

Literature Records: Nil.

Distribution: Coastal regions of E. Australia from Cape York (Qld.) to just E. of Melbourne.

Denisonia superba (Günther)

Denisonia superba complex: This complex is restricted to the cool and cold temperate zones of the Bassian subregion (as defined in the introduction). There are two taxa in the complex, and these are represented by widespread and largely allopatric populations which overlap along the southern margin of the Eastern Highlands in E. Victoria. Although the two forms overlap extensively, especially to the NE. of Melbourne, sympatric populations have not been found to date. However, it appears that the two taxa have reached species status as no evidence of hybridization has been observed in specimens from the overlap zone. One taxon occurs in Tasmania, the Bass Strait islands, S. Victoria and SE. South Australia. This taxon (apparently the nominal form, as most of the type series came from Tasmania) has been designated the 'Lowlands Form' as where the two taxa contact, it is restricted to the lower altitudes. The second taxon occurs in the highlands of E. Victoria and E. New South Wales, with isolates in the Mt. Lofty Ranges and Kangaroo Island, South Australia. This is the only taxon found in East Gippsland and it has been designated the 'Highlands Form' as it is restricted to the higher altitudes where the two taxa contact. Rawlinson (1967) has previously referred to this form as *Denisonia sp. nov.*

Highlands Form

Specimens Examined: (MUZD) Native Dog Plain, 4½ miles SW. of Mt. Cobberas; Morass Ck, 5 miles S. of Mt. Misery; 6 miles N. of Benambra; 4 miles

S. of Wulgulmerang; 3 mile S. of Gelantipy. (NMV) Benambra; Gelantipy; Bruthen.

Specimens Observed: 2 miles N. of Wulgulmerang; 4 miles N. of Gelantipy; Bonang; 3 miles N. of Sardine Creek.

Literature Records: Nil.

Distribution: *Highlands form*: Highlands of SE. Australia from New England Tableland (N.S.W.) to Lake Mountain (Vic.). There is an isolate in the Mt. Lofty Ranges and on Kangaroo Is., South Australia. *Lowlands form*: Highlands of S. Gippsland and coastal plains of W. Gippsland, SW. Victoria and SE. South Australia. This form also occurs on the Bass Strait islands and in Tasmania.

Notechis scutatus (Peters)

Notechis scutatus complex: The genus *Notechis* is restricted to the Bassian subregion (*sensu* Serventy and Whittell, 1951). Two species and four subspecies have been described in the genus. However results of recent work (Rawlinson, 1967 and unpublished) have indicated that there are only two taxa—the two described species, *N. ater* and *N. scutatus*. *N. ater* has a disjunct distribution from Tasmania, through South Australia to S. Western Australia, while *N. scutatus* has a continuous distribution throughout the warm and cool temperate SE. of Australia. The latter taxon is the only one found in East Gippsland.

Specimens Examined: (MUZD) Morass Ck, 5 miles S. of Mt. Misery. (NMV) Orbost; Lakes Entrance; Croajingolong.

Specimens Observed: Nil.

Literature Records: Nil.

Distribution: SE. Australia inside the 20 inch isohyet from Mt. Tambo (SE. Qld.) to Kangaroo Is. (S.A.). A closely related species, *N. ater*, occurs on Tasmania and the Bass Strait islands; the Flinders Ranges, Yorke and Eyre Peninsulas and offshore islands, South Australia; and SW. Australia (Rawlinson, 1967).

Pseudechis porphyriacus (Shaw)

Specimens Examined: (MUZD) 8 miles N. of Murrindal; 12 miles W. of Cann River; Lake Tyers. (NMV) Gelantipy; Tullochard, near Gelantipy.

Specimens Observed: 2 miles N. of Wulgulmerang; 15 miles N. of Buchan; 8 miles NE. of Genoa; 3 miles W. of Cann River; 1 mile W. of Cann River; 8 miles N. of Orbost; Bell Bird Creek; 5 miles W. of Nowa Nowa; 8 miles E. of Orbost.

Literature Records: Nil.

Distribution: Coastal regions of E. Australia from Cape York (Qld.) to about Sale (Vic.). Crosses the Eastern Highlands in Queensland and penetrates along the Murray-Darling River system into South Australia. Also occurs along the inland margin of the Eastern Highlands in SE. Australia, penetrating into SW. Victoria through the Kilmore Gap.

Discussion

Twenty-nine reptile species are recorded from East Gippsland in this paper, 22 for the first time. The distributional data provided above for these species can be discussed along two main lines to reach separate, but related, conclusions. This is done under two headings:

1. Main reptile distribution patterns in East Gippsland.

2. The East Gippsland reptile fauna in relation to Australian zoogeographic subregions.

Before continuing, several points should be clarified. The present paper deals only with the reptiles of East Gippsland, but the ideas developed below are an expansion of previously published work on the reptiles of SE. Australia (Rawlinson, 1966, 1967). A checklist of the reptiles of SE. Victoria (Gippsland) and SW. Victoria was provided in one of these papers (Rawlinson, 1967, Table 1), but this has since proved inaccurate on four counts (Rawlinson, unpublished): 2 species, *Egernia luctuosa*, and *Morelia argus argus*, can now be added to the SE. Victorian list, bringing the total number of species to 33; 1 species, *Emoia spenceri*, can be added to the SW. Victorian list and 1 species, *Leiolopisma metallicum*, can be removed, the total number of species remaining at 30. On the latter point, recent evidence (Rawlinson, unpublished) has suggested that *L. metallicum* is absent from Western Australia, records for this species apparently being

TABLE 1

Distribution patterns of East Gippsland reptile species

Species	Thermal Zones occupied in East Gippsland			Zoogeographic Distribution		
	Warm Temperate only	Cool Temperate only	Warm and Cool Temperate	Exclusive Bassian	Transitional from Torresian	Transitional from Eyrean
Chelodina longicollis	+	—	—	—	+	—
Amphibolurus diemensis	—	+	—	+	—	—
A. muricatus	+	—	—	+	—	—
Physignathus lesueuri	+	—	—	—	+	—
Egernia cunninghami	+	—	—	+	—	—
E. saxatilis	—	—	+	+	—	—
E. whitei	—	—	+	+	—	—
Emoia spenceri	—	+	—	+	—	—
Hemiergis decresiensis	+	—	—	+	—	—
Leiolopisma delicata	—	—	+	+	—	—
L. entrecasteauxi	—	+	—	+	—	—
L. guichenoti	—	—	+	+	—	—
L. mustelinum	—	—	+	+	—	—
L. trilineatum	—	—	+	+	—	—
L. weeksae ?	—	+	—	+	—	—
Siaphos maccoyi	—	+	—	+	—	—
Sphenomorphus tympanum (Cool Temperate Form)	—	+	—	+	—	—
Sphenomorphus tympanum (Warm Temperate Form)	+	—	—	+	—	—
Tiliqua casuarinae	—	—	+	+	—	—
T. nigrolutea	—	+	—	+	—	—
T. scincoides	+	—	—	—	+	—
Varanus varius	+	—	—	—	+	—
Morelia argus argus	+	—	—	+	—	—
Demansia textilis	+	—	—	—	—	+
Denisonia coronoides	—	+	—	+	—	—
D. nigrescens	+	—	—	—	+	—
D. superba	—	+	—	+	—	—
Notechis scutatus	—	—	+	+	—	—
Pseudechis porphyriacus	+	—	—	—	+	—
Total	12	9	8	22	6	1

attributable to *L. guichenoti*, or a closely related form. The reptilian fauna of SE. Victoria thus includes at least 33 species, and 29 of these are known to occur in East Gippsland, the absentees being *Egernia luctuosa*, *Leiolopisma metallicum*, *Rhodona bougainvilli* and *Denisonia superba* (Lowlands form).

1. Main Reptile Distribution Patterns in East Gippsland

East Gippsland can be divided into two thermal zones (warm and cool temperate) as a consequence of the low and high altitudes (see introduction). The locality data provided above indicate that 12 species are restricted to the warm temperate zone, 9 species to the cool temperate zone and 8 species occur in both zones (see Table 1). This breakdown of East Gippsland reptile species agrees with their distribution in the warm and cool temperate zones of the Bassian subregion outside East Gippsland.

2. The East Gippsland Reptile Fauna in Relation to Australian Zoogeographic Subregions

The most generally accepted scheme for subdividing Australia into zoogeographic subregions is that proposed by Spencer (1896) and subsequently modified by Serventy and Whittell (1951) (see reviews in Keast, 1959 and Littlejohn 1967). In this scheme, four subregions are recognized: the temperate Bassian and South-Western subregions; the tropical Torresian subregion; and the arid Eyrean subregion. Burbidge (1960) has proposed almost identical divisions for the principle floristic zones in Australia: Tropical zone (= Torresian); Temperate zone (= Bassian and South-Western); and Eremaean zone (= Eyrean). As was mentioned in the introduction, Gippsland lies in the Bassian zoogeographic subregion, and Rawlinson (1966, 1967) has described its reptile fauna as Bassian, but without providing the data and principles on which this conclusion was based. Detailed distributional data on the reptiles of East Gippsland have been provided above, and the discussion can be developed to explain how these data fit the Bassian subregion concept.

Darlington (1957, pp. 419-428), when discussing the concept of zoogeographic regions, states: 'that the faunal regions are designed to represent the main features of distribution of *existing* animals, and that, although the causes that have produced present distributions lie in the past, any attempt to combine the past with the present in one system of regions must lead to confusion'. Thus zoogeographic regions must be based on static patterns, and Darlington (op. cit.) concludes: 'The system of faunal regions, then, represents the average, gross, pattern of many different animals with more or less different distributions'. This effectively summarizes the basis for dividing the Earth into zoogeographic regions, but it does not give a working idea of how such regions can be recognized. Keast (1959, p. 129), following Mayr (1945), provides definitions of regions and subregions based on the faunal elements to be expected: 'A zoogeographic region may be defined as a geographic subdivision of the Earth that is the home of a peculiar fauna. Such a region is characterized by the presence of many endemic genera and families and by the absence of the characteristic genera and families of other zoogeographic regions. A sub-region or faunal province by contrast can be held to be a somewhat lesser division, characterized by a series of endemic forms of lesser degree'. Using this definition, Rawlinson (1966) showed that there are great differences between the Bassian and Eyrean reptile faunas at the specific, generic and familial levels; and a similar, but less marked, difference exists between the Bassian and Torresian reptile faunas (Rawlinson, unpublished).

Few Bassian reptile taxa (especially species) have distributions co-extensive with the boundary of the Bassian subregion and there is no sharp cut-off of distributions at the Bassian boundary. This is not surprising, for Darlington (1957, p. 198), when discussing transitions and barriers in the distribution of reptiles between faunal regions, states: 'Where different faunas of reptiles meet there are not sharp boundaries but broad areas of transition—overlapping with progressive subtractions'. However, this presents another problem: which of the reptilian taxa occurring within the boundaries of the Bassian subregion are Bassian faunal elements, and how do the remaining taxa fit into the subregion concept? Darlington (1957, pp. 453-456) provides an answer to these questions when he points out that where two faunal regions are separated by partial barriers, complex transitions are to be expected, with overlapping of faunal elements and progressive subtraction in both directions. As a result of these transitions, the taxa in two partially separated regions can be divided into three categories:

1. Exclusive taxa: occur in one region only; these taxa delimit the region.
2. Transitional taxa: occur in both regions, but are extensive in one region and limited in the other.
3. Shared taxa: occur throughout both regions.

Burbidge (1960) recognized the significance of transition zones when she divided Australia into the three principal floristic zones mentioned earlier. Between these zones she has areas of transition which are divided into two categories:

(a) Interzones 1, 2 and 3; between the SW. Temperate and Eremaean, SE. Temperate and Eremaean and Tropical and Eremaean zones respectively. These are apparently simple areas of overlap with progressive subtraction in both directions.
(b) MacPherson MacLeay overlap; between the Tropical and SE. Tem-

TABLE 2

Zoogeographic elements present in the East Gippsland reptile fauna

Possible Distribution Pattern	Number of Taxa			
	Species	Super-Species	Genera	Families
1. Exclusive Bassian	22	3	1	—
2. Transitional Bassian to Torresian	—	—	1	—
3. Transitional Bassian to Eyrean	—	—	—	—
4. Transitional Bassian to Torresian and Eyrean	—	—	—	—
5. Transitional Torresian to Bassian	6	1	3	1
6. Transitional Eyrean to Bassian	1	—	1	—
7. Transitional Torresian and Eyrean to Bassian	—	—	5	2
8. Transitional Torresian to Eyrean and Bassian	—	—	—	—
9. Transitional Eyrean to Torresian and Bassian	—	—	—	—
10. Shared Bassian and Torresian	—	—	1	—
11. Shared Bassian and Eyrean	—	—	—	—
12. Shared Bassian and Torresian and Eyrean	—	—	4	3
Total	29	4	16	6

perate zones. This area is apparently a mosaic of Tropical and Temperate communities with progressive subtraction in both directions.

As the Bassian subregion is only partially separated from the adjacent subregions (Eyrean and Torresian), exclusive, transitional and shared taxa (species, genera and families) may be expected in the fauna. The East Gippsland reptile fauna then, could contain 12 zoogeographic elements, but Table 2 shows that only 7 of these possible categories are represented; 3 at the specific level, 2 at the superspecific (*sensu* Mayr, 1963) level, 7 at the generic level and 3 at the familial level.

Of the 29 species recorded from East Gippsland, 22 are exclusive to the Bassian, 6 are transitional from the Torresian and 1 is transitional from the Eyrean. These are all listed in Table 1.

At the superspecific (*sensu* Mayr, 1963) level, there are members of 4 species complexes present in East Gippsland; 3 (the *Egernia cunninghami*, *Denisonia superba* and *Notechis scutatus* complexes), are exclusively Bassian; and 1 (the *Sphenomorphus quoyi* complex), is transitional from the Torresian to the Bassian.

At the generic level, the East Gippsland reptilian fauna has: 1 exclusive Bassian genus (*Notechis*); 1 genus transitional from the Bassian to the Torresian (*Leiolopisma*); 3 genera transitional from the Torresian to the Bassian (*Chelodina*, *Emoia* and *Siaphos*); 1 genus transitional from the Eyrean to the Bassian (*Hemiergis*); 5 genera transitional from the Torresian and Eyrean to the Bassian (*Physignathus*, *Varanus*, *Morelia*, *Demansia* and *Pseudechis*); 1 genus shared between the Bassian and Torresian (*Sphenomorphus*); and 4 genera shared between the Bassian, Torresian and Eyrean (*Amphibolurus*, *Egernia*, *Tiliqua* and *Denisonia*).

At the familial level, the East Gippsland reptilian fauna has: 1 family transitional from the Torresian to the Bassian (*Chelyidae*); 2 families transitional from the Torresian and Eyrean to the Bassian (*Varanidae* and *Boidae*); and 3 families shared between the Bassian, Torresian and Eyrean (*Agamidae*, *Scincidae* and *Elapidae*).

The above analysis of the East Gippsland reptilian fauna reveals that it is essentially Bassian in nature, but the presence of the warm temperate zone has enabled certain transitional Torresian and Eyrean taxa to become established. The evidence presented indicates that it has been easier for Torresian taxa to become established in the area. These points are best exemplified at the specific level where 76% of the species are exclusively Bassian, 21% are transitional from the Torresian and 3% are transitional from the Eyrean. The higher taxonomic categories present a less clear picture: 3 species complexes (or superspecies, *sensu* Mayr, 1963) are exclusively Bassian; 1 genus is exclusively Bassian and 1 genus is transitional from the Bassian to the Torresian. All other taxa are transitional from, or shared with, the Torresian or Eyrean, but a stronger link with the Torresian is evident.

Conclusions

1. East Gippsland can be divided into two thermal zones, the warm and cool temperate, each of which has its own reptilian fauna.

2. Following the principles for zoogeographic regions and subregions laid down by Darlington (1957) and Keast (1959), the East Gippsland reptile fauna is considered to be Bassian in nature, but the warm temperate zone has enabled transitional Torresian and Eyrean taxa to become established.

Acknowledgments

Many of the specimens used in this study were kindly provided by: Dr. M. J. Littlejohn and Messrs. R. S. Frankenberg, A. A. Martin and D. S. Woodruff, Department of Zoology, University of Melbourne; Mrs. R. S. Frankenberg and Mr. R. N. Webb, Department of Botany, University of Melbourne; Professor I. W. B. Thornton and Mr. I. F. Spellerberg, School of Biological Sciences, La Trobe University; and Messrs. R. Warneke and J. H. Seebeck of the Victorian Fisheries and Wildlife Department.

The Director, Mr. J. McNally, Miss J. Dixon and Mr. A. J. Coventry of the National Museum of Victoria, provided access to specimens in their care.

Most of the data used in this paper was collected while the author was in receipt of a Commonwealth Post Graduate Award in the Department of Zoology, University of Melbourne.

The author is indebted to Dr. M. J. Littlejohn for reading the manuscript and suggesting alterations.

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8

Forestry in East Gippsland

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Summary

Since the early years of settlement most of the forest of East Gippsland has sustained damage from wild fires. The opening of the railway to Orbost saw the commencement of selective utilization, which resulted in further degradation of adjacent forest stands. Despite geographical isolation a strong sawmilling industry has transferred into the region during the past twenty years, and currently produces 25 per cent of the State hardwood log output. Roading for utilization and fire protection has been developed in the forest area, but access to remote areas is still inadequate. Sawmilling has been organized so that significant economic advantage has been derived by communities with limited opportunity to develop by expansion of agriculture. Substantial agricultural expansion depends on alienation and development of land at present completely forested and contributing to the current log requirements of the sawmilling industry. Silvicultural improvement of the forest can be achieved by removal of residual trees and waste wood for utilization by a wood pulp industry.

Forest Reservation

In East Gippsland, reservation of large areas of forest has been possible because of remoteness from the pressure of expanding settlements, and difficulty of terrain. By the schedules of the 1907 Forests Act a total of almost 370,000 acres was reserved for forest purposes as follows:

Forest Blocks at Bendoc	70,500 ac.
„ „ „ Noorinbee	139,608 ac.
„ „ „ Dellicknora	10,660 ac.
„ „ „ Nerran	35,600 ac.
„ „ „ Orbost	30,440 ac.
„ „ „ Wulgulmerang	3,270 ac.
„ „ „ (Part) Enano	11,470 ac.
„ „ „ (Part) Tambo	60,620 ac.
„ „ „ (Part) Colquhoun	6,637 ac.
„ „ „ Tildesley	860 ac.
Total	369,665 ac.

The majority of these forest blocks were remote from markets and some of the areas were apparently reserved, despite poor tree growth, as watershed protection areas.

With the construction of the railway to Orbost (1916), the forests within 10-15 miles of the line were tapped and utilized to produce sleepers and other hewn timbers. The undoubted value of these forests to this industry resulted in the dedication of 17,590 acres for forest purposes to the NE. of Nowa Nowa in 1916 and a further 30,000 acres W. of Orbost in 1930.

Minor adjustments were made to forest boundaries in 1935 by the excision of almost 3,000 acres in the vicinity of farming settlements; but a valuable belt of high quality forest of some 20,500 acres was reserved in the Goongerah-Bendoc area. In the Derndang-Wangarabelle area 3,716 acres of box forest was reserved in 1938, and subsequently over many years, yielded box poles and piles, and more than one million superficial feet of logs to provide durable timber used in the manufacture of Victorian Railways rolling stock.

Abandoned farms in the dense forests of Murrungowar and Kuark added 3,690 acres to the forest reserve in 1940, and an additional 5,030 acres in 1949. The potential of this area for growth of forest can be gauged from the fact that the 80-90 ft test piles driven at Kings Bridge were cut here, as were four 120 ft poles, required for developmental structures at Woomera (1956).

With the support of Sir Albert Lind, Minister of Forests, and member for East Gippsland, an area of 163,000 acres of forest extending from Orbost E. to beyond the Bemm River was reserved in 1951. This was the largest block of forest reserved in East Gippsland this century. Permanent reservation has ensured log supplies to local millers and the expenditure of Forests Commission funds in managing and regenerating the forest. The last major addition to the forest estate was in 1960 when 46,500 acres of prime forest on the Errinundra tableland was reserved. Since 1930 a total of 10,538 acres of reserved forest area has been relinquished to adjust forest boundaries and to remove from the forest estate areas with low potential for forest growth.

The net area of forest reserve in eastern Gippsland is:

Gazetted in 1907	369,665 ac.
Subsequent dedications	289,964
	659,629
Less excisions	10,629
Permanently reserved	649,000 ac. net.

This area comprises 11½ per cent of the total reserved forest area in the state, but is 25 per cent of the area of this part of East Gippsland.

Land tenure within the region is as follows:

Protected Forest (unoccupied Crown lands)	1,611,000 ac.	61%
Reserved Forest	649,000 ac.	25%
National Parks	40,000 ac.	2%
Alienated Lands	300,000 ac.	12%
(4,100 sq. mls.)	2,600,000 ac.	

The imbalance between the area of permanent farmland, with its scattered population and small townships, and the huge area of forested land, indicates the degree of development that is still required in the region and the importance of the forest resource. A large proportion of the Crown land is forested and capable of yielding forest produce at the present time. However, the long rotation necessary to replenish the forests on sites of low productivity would not warrant permanent reservation, nor intensive management. Other large areas of Crown land, particularly in the Snowy River valley, do not carry merchantable timber and due to ruggedness of terrain are quite unsuitable for conversion to farmland. The vegetation forms a protection forest for these sites, and in future, portions of these areas may be reserved as National Parks or as Wilderness Areas.

The crop on Crown land is of importance to the timber industry at the present time, but in the future when the permanent forests are managed to produce the maximum growth from the site, it can be anticipated that Crown lands, and even some forest reserves of lower timber production potential, may be released for agricultural purposes.

Early Utilization

Pit sawing of timber at Bendoc, when gold mining was in progress there in 1852, may have been the earliest forest utilization in the region. A sawpit has also been discovered on the Nunniong tableland under Mt. Bindi; so it is reasonable to assume that pit sawing to produce better finished building and construction timbers may have been an adjunct to most of the early permanent settlements.

The opening of the Melbourne-Sale railway in 1878 and its extension to Bairnsdale in 1888 provided a ready outlet for produce cut from the forests adjoining the Gippsland Lakes. Milling had developed there previously to supply local needs, but now it was practicable for produce to be cut near the Lakes and transported by water and rail to an increasing market. At this distance from the market however, only special timbers, not readily available elsewhere, were in demand.

Eucalypt species that could supply heavy construction timbers, either sawn or hewn, were sought through these forests—red iron-bark, grey box, red gum and red box. The produce ranged from the red gum paving blocks for Melbourne streets to piles of iron-bark and box for harbour works; sawn red gum planks 12 in. x 2 in. and 35 to 45 ft long; and red gum beams for dock gates—42 ft long and 24 in. square. There is a record too of a grey box keel 66 ft long cut in these forests.

With this type of utilization the nearest and best trees were selected. The best tree was one with least defect that could supply the most timber for the effort of felling it. This type of selective logging left only trees of poor form and quality or those too remote for harvesting.

Until the railway extended to Orbost in 1916, the only forest utilization, other than for domestic needs, was in the vicinity of Lake Tyers, at Tabbara, and at Bendoc. However, large areas of forest received severe damage from the recurrent fires that escaped from the settlers' clearing operations or were lit to encourage growth of cattle feed on the floor of the forest.

Forest Fires

Forest fires have always been a factor of the environment of the region. In the past these had originated principally from natural causes, such as lightning; occasionally from the use of fire by aboriginals. Considering the uniform age of a forest stand of the ash group of eucalypts occurring in the region and the silvicultural requirement of the species for regeneration, it is evident that fires swept the forest at intervals during the pre-settlement period.

After the settlement of the limited areas of sparsely forested land, the pioneers turned to the less dense forest of the coastal plain and to the highly fertile soils of the river flats and valleys. The massive logs and accumulated debris were burned to prepare the land for pasture. This fuel was rarely dry enough to burn satisfactorily, except in summer, and inevitably these clearing fires escaped. Scars in the forest from escape fires are clearly shown by the dead stags and dead-topped trees in the Combienbar and Errinundra valleys.

Stock was grazed in the forests around settlements, and experience had shown that cattle would thrive on the regeneration of grass, herbs and shrubs following a fire. Two to three years after burning, palatable feed became scarce. Another section of the forest would then be fired because the accumulation of at least five years forest litter was necessary before burning could be repeated successfully on any area.

Many of the Crown lands were made available by the Lands Department as grazing leases of some 30,000 acres each. It was inevitable that systematic burning was used to promote the growth of forage. Although cattlemen wanted a localized fire which limited the far ranging of stock, the timing of the burn was difficult, and instead of a low intensity fire burning under climatic controls late in the season, forest fires often raged out of control.

The chaotic structure of the forest stands of the foothills and mountain slopes is a result of repeated burning of the forests in the past. There are few areas with no evidence of past fires, and many which have been swept by fires recurrent and intense. The species of the coast and foothills are fire resistant, and although mature trees are only sometimes killed by burning, dense regeneration of eucalypt saplings and scrub is often induced by fire.

Later fires reduce this sapling regrowth, but the survival of stems that regenerate new crowns, or coppice from the butt, with the older trees, overstocks the forest site. Older trees with fire scars are susceptible to attack by termites, longicorn beetles and fungi; and the timber has suffered degrade through the presence of kino in the form of gum veins and pockets in the wood. Competition in the over-stocked stands results in retarded growth of all stems, rendering them susceptible to insect and fungal attack.

Recurrent fires sweeping through regeneration of varying age and stocking, followed by a fresh crop of regeneration, have caused a wide variety of irregular age classes and a variety of stocking densities.

The Hewn Timber Industry

The extension of the railway to Nowa Nowa (1914) and to Orbost (1916) opened up forests of 'hardwood' eucalypt species acceptable for railway sleepers, viz: red iron-bark (*E. sideroxylon*, A. Cunn.), Gippsland grey box (*E. bosistoana*, F.v.M.), red box (*E. polyanthemos*, Schau), and yellow stringybark (*E. muelleriana*, Howitt).

Beams hewn from these species were also in demand for heavy wooden constructions, wharfs, bridges, etc. Some control was exercised in the forest to ensure that immature trees were not utilized and that larger trees were reserved to supply beam timber.

The sleeper hewer was a contractor to the Railways Department on piece work, and largely dependent for his livelihood on the Railway requirement of sleepers. The more skilful hewers were able to increase their earnings by supplying beams and octagonal dressed poles.

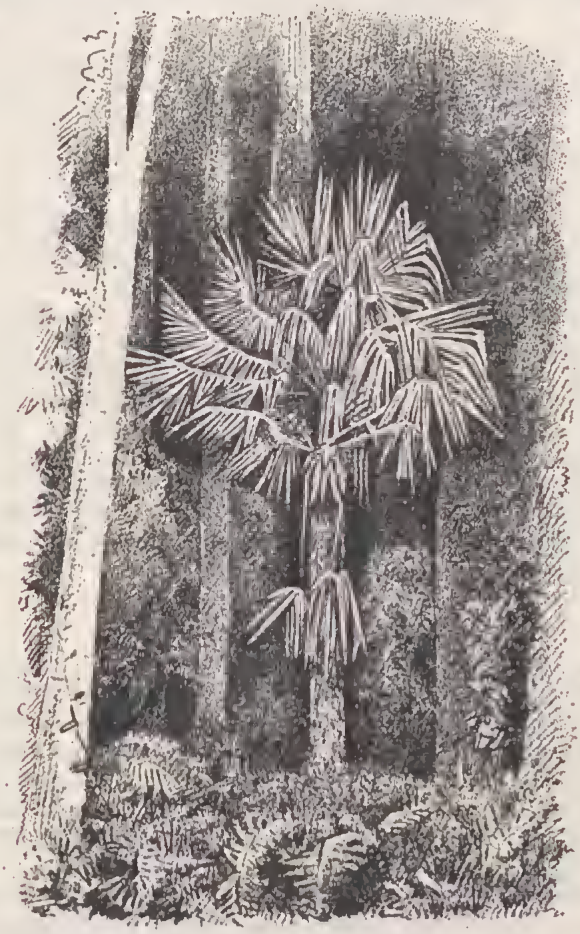
By 1920 some 60 per cent of the State requirement of hewn beams and 25 per cent of the sleepers were being produced from the east of Nowa Nowa. The revenue derived however, was only 3 per cent of the Forests Commission's income. During the depression, Railway requirements of sleepers were allocated in small lots or quotas to up to 320 hewers in the area to provide a subsistence income. This quota system has continued to be a feature of the contract between the hewer and the Railways Department.

As suitable timber for hewing became depleted within wagon reach of the railway, the sleeper carters invested in motor lorries. By 1930 timber stands 20 miles from rail were being utilized and the Forests Commission by 1935 was assisting to establish roads to suitable stands of timber at greater distances.

In view of increasing difficulty in obtaining supplies of the 'hardwood' sleepers the Railways in 1938 accepted supply of sleepers cut from southern mahogany (*E. botryoides*, Sm.), white stringybark (*E. scabra*, Dum-Cours.), and messmate stringybark (*E. obliqua*, L'Her), and in addition in 1943, Yertchuk (*E. consideniana*, Maiden), became an acceptable species. Any 'hardwood' sleepers supplied fetched a slight premium in price.

During the 1939-45 war period the Railways requirement of sleepers was reduced to a minimum and only 55 hewers were in employment in the area.

The post-war period saw an increase in sleeper prices to attract hewers into the industry, but the output of sleepers per man did not increase correspondingly. The reverse was the case and the hewer worked shorter hours to obtain sufficient sleepers to provide an income slightly better than day wages. Further concessions were made by the Railways in 1946 when mountain grey gum (*E. cypellocarpa*, L. Johnson), blue gum (*E. bicostata*, Maiden, Blakely and Simmonds), and red stringybark (*E. macrorrhyncha*, F.v.M.) were accepted, and in 1948 silvertop (*E. sĭĕberi*, L. Johnson), in an attempt to overcome deficiencies in railway track main-



A young cabbage tree palm which has not yet grown above the tops of the surrounding trees. (*W. B. Spencer, 1889.*)

tenance brought about by the war years. In 1947 there were 105 hewers in the industry, but the Railways requirement of sleepers exceeded the supply.

In order to overcome deficiencies in supply the Railways sought sawn sleepers from the saw mills and introduced mobile benches into the forest to saw sleepers from cull trees. This permitted an opportunity for unskilled New Australians and, as well as the chain saw, they introduced the mobile swing saw to the industry. This marked the end of the need for the hewer's particular skill, and during the decade from 1950 mechanization has resulted in a revolution of the sleeper industry.

The Railway requirement for sleepers that had been in the order of 250,000-350,000 per year pre-war increased in post-war years to 500,000-600,000 per year. Until 1950 East Gippsland supplied some 25 per cent of the requirement but since that date, 45-50 per cent of the total sleepers produced have come from east of Nowa Nowa. The work force engaged in the industry has varied between 102 in 1950 to 192 in 1955, but 1966 saw a decline to only 70, following a decrease in the requirement by the Railways.

The 1955 pattern of production that supplied 278,000 sleepers (46 per cent of State requirement), was 3 benches, 28 swing saws and 75 broad-axemen, a work force of 192. With the industry re-established and capable of supplying the annual requirement, the Railways in 1957 ceased to accept sleepers from those species introduced after 1946, and from messmate. By 1966 the broadaxe had practically disappeared, but only 126,800 sleepers (26 per cent of requirement) were produced by 70 operators.

In addition to sleepers for the Victorian Railways the period 1940-56 saw the production east of Genoa of sleepers for export from Eden to New Zealand. At various periods sleepers have been cut for the Melbourne and Metropolitan Tramways Board and for the State Electricity Commission.

The output of hewn beams, once of considerable importance in this area, has now declined, as such timbers can be largely replaced by sawn products.

During the past 50 years the hewing industry has required the utilization of from 5-15 million superficial feet (s.ft) Hoppus Log Volume (H.L.V.) per year for the production of sleepers, beams, crossing timbers etc. Despite additional species being acceptable for sleepers for a period, the continuous selection of merchantable trees for conversion has resulted in degeneration of the forest stands of the coastal plain and lower foothills. The remaining faulty old trees and suppressed stems of poor form produce only inferior wood and distance from markets has made this economically unusable.

The Sawmilling Industry

Sawmilling was by 1946 centred at Nowa Nowa (one mill) Cabbage Tree Creek (one mill), Orbost (one mill), Bendoc (three mills) and Bonang (one mill), but the annual log requirement was less than five million s.ft per year. There was an intermittent demand for logs to supply special class timbers and up to 500,000 s.ft H.L.V. was despatched by rail to Melbourne. Log despatches comprised logs of blue gum to State Electricity Commission, iron-bark and messmate to Victorian Railways, and even kanooka (*Tristania laurina*, R.Br.) for manufacture of tobacco pipes.

Sawn timber was largely despatched to towns close to the area but a proportion found a market in the Latrobe Valley. The Public Works Department, Harbour Trust and Country Roads Board had a firm requirement for timber of special dimensions cut largely from yellow stringybark. Silver wattle (*Acacia dealbata*, Link.) case material was supplied for fish cases at Eden and Sydney, and for butter boxes at local factories and further afield.

The manpower shortage during the war restricted sawmilling in the region, and the majority of the mills in the State were geared to the salvage of the mountain ash forests destroyed in the 1939 fires. Although milling of salvage logs continued until the fifties, by 1946 the growing demand for timber and the depletion of logs from salvage sites, caused millers from the central areas of the State to seek log allocations from the forests of East Gippsland. After formulation of cutting plans, the Forests Commission granted log allocations and 1947 saw the first of these new sawmills in production at Cabbage Tree Creek. Two more mills commenced in Orbost in 1948, another in 1949, and in 1950 two more in Cabbage Tree Creek and another at Waygara.

The industry that transferred to the region had well-established customers, marketing procedures, and timber yards. Management and employees were skilled in logging and milling, and had the advantage of techniques developed during the ash salvage programme: the bulldozer for snigging and road construction, the articulated timber jinker for log cartage, and the recently developed chainsaw for improved log production.

The trickle of sawn timber from East Gippsland now became a steady stream as annual intake of logs climbed by 1950 to a volume of 25 million s.ft H.L.V. Although a large volume of production for this region, it represented only 7 per cent of hardwood log intake for the State. When the economic recession occurred in 1952, thirty-four sawmills were located in twelve settlements in the region (see Appendix 1).

Despite decreased production due to economic restrictions over the ensuing two years, additional mills opened at both Waygara and Cabbage Tree Creek (36 total). In 1955 log intake to these mills had climbed to 65 million s.ft H.L.V., representing 15 per cent of the State hardwood log intake. Additional mills were established in 1956 at Bendoc, Sardine Creek and Club Terrace (39 total).

Except at Bendoc and Gelantipy the East Gippsland mills were established to draw logs from the forests of the coastal and foothill zones. These forests yielded scantling and a useful proportion of merchantable timber, and special construction timber from durable species. The harvesting operation was by tree selection, which although preserving advanced regrowth, results in the faulty and suppressed stems becoming an increasing proportion of the forest.

High grade timber suitable for production of quality boards, dressed floorings, lining, and joinery, was produced at Gelantipy, Bendoc and eventually at Buchan and Nowa Nowa when the forests of Nunniong tableland were opened to utilization.

During the past decade additional allocations of logs from the coastal and foothill forests have been made, principally for mills establishing in Cann Valley, Bemm River, etc. The forest of the Errinundra tableland and adjacent valley heads contains a high proportion of shining gum (*E. nitens*, Maiden), cut tail (*E. fastigata*, Deane & Maiden), mountain ash (*E. regnans*, F.v.M.) and alpine ash (*E. delegatensis*, R. T. Baker), and this forest was reserved from utilization.

During the past few years supplies of high grade timber in the Central Highlands and North Gippsland have diminished, and allocations of logs from the high quality forest of the Errinundra tableland have now been made. Additional plants to mill this timber have been established, or are projected for early construction.

At the present time forty-three sawmills are based on sixteen settlements in East Gippsland. (See Appendix 1.) During the past financial year, out of an available allocation of 121 million s.ft, these mills utilized 107 million s.ft, contributing 25 per cent of the State hardwood log requirement.

Forests Commission Activities

(a) Fire Protection

Supervision of forest operations in East Gippsland was strengthened in 1920 by the addition of professional foresters to the staff. Although responsible for fire protection in the whole of the region, the forester was not aware of fires which often occurred in remote areas. Telegraphic communication was lacking, and horse transport precluded the possibility of reaching a fire when it was at a controllable size. Additional staff, recruited from among experienced forest workers, provided closer supervision of utilization and permitted development of fire protection and fire suppression, within the vicinity of the railway and southern settlements.

To facilitate the expansion of the hewing industry to more remote forests, construction of extraction roads to a developmental plan began about 1935, and the forester was issued with motor transport to permit more adequate supervision. There were less than 60 miles of trafficable road within the forested area in 1939, although there were many hundreds of miles of abandoned sleeper tracks which were suitable for rapid improvement for light traffic.

The havoc of the 1939 fires gave impetus to the construction of roads through the forests, primarily to provide a means of rapid access to fires. Plans for these roads embraced the whole of the State Forest and with the provision of such earth moving machinery and labour as was available during the war years, old sleeper tracks, mining and coach roads were opened up and improved to the extent of some 200 miles a year.

Concurrently, fire spotting towers were erected across the area linked by over two hundred miles of Forests Commission telephone line. It was practicable for tower men in Cann Valley to check smoke sightings with towers in Orbost, Nowa Nowa and Bruthen areas.

During post-war reconstruction, earth-moving plant became more readily available and the labour force increased to more than seventy men. Up to fifty miles of roads on entirely new alignments and across difficult forest terrain were completed each year. With the introduction of four-wheel-drive vehicles after 1946 the roading plan was amplified by the inclusion of a system of bulldozer constructed 'jeep' tracks which provided for rapid transport of crews to fires in remote areas.

Forestry operations have provided employment for many years for at least fifty residents of sixteen settlements in and adjoining the region. As well as roads and tracks constructed by the Forests Commission for fire protection, logging units have been closely roaded by the sawmilling industry for log extraction. Within the forested area there are now more than 5,000 miles of vehicular access track and a considerable further mileage of abandoned track that can be opened quickly for use in a fire emergency.

Although roading intensity is high within the vicinity of settlements, main through roads and logging areas, there are remote areas into which access is still being developed. Construction of further access, to permit rapid movement of fire crews, will for some years be a feature of Commission developmental work in East Gippsland.

(b) MANAGEMENT AND SILVICULTURE

As previously indicated, the forest of a large part of the region has become decadent through excessive firing, overstocking, and where selective felling had been practised, through increase in the proportion of defective trees in the crop.

The primary objectives of management must be the replacement of decadent and unhealthy stands with vigorous forest of maximum productivity, yielding highest quality mill logs, round timbers and special construction timbers, while preserving site factors and stream flow characteristics.

Rehabilitation of the forest requires the removal of all unproductive trees as well as those yielding merchantable logs, and the establishment of regeneration with a regular distribution of age classes.

Logging operations are closely supervised by forest officers to ensure the felling of all trees likely to yield logs suitable for milling. Since 1954 the felling of doubtful trees has been encouraged by the Forests Commission, by payment for the felling of specified trees which subsequently failed to yield a merchantable log. Millers requiring logs in addition to their normal allocation are permitted to 'scavenge' for logs from trees remaining on areas that are considered completely cut-over. Mobile benches too, have been used in the forest, to saw sleepers from trees left standing after logging operations have been completed.

In spite of close utilization a high proportion of the original forest remains on most cut-over areas and impedes the development of regeneration.

(c) ORGANIZATION OF SAWMILLING

Before 1939 it was usual for a sawmill to be located close to, or within, the forest from which logs were obtained. Mill workers, and often their families, resided at the mill and where the labour force was large some facilities such as school and post office were also established. When accessible mill logs were utilized, the mill shifted to another part of the forest or to another area. The living conditions of mill workers were primitive and lacking amenities. Adjoining communities derived little lasting benefit from the temporary operation of the mill.

The destruction of mills and loss of life in the bush fires of 1939 necessitated that in future mills be located outside the forest, and that fire protection safeguards be implemented to protect life and property. The development of machinery for roading into forest stands and the cartage of logs for a considerable distance permitted the sawmilling industry to be organized to the benefit of the employer, the employees and the rural communities.

The utilization plan implemented by the Forests Commission for the East Gippsland forests defined Logging Units from which saw-millers were granted annual allocations of logs. The plan specified the locations at which the logs were to be converted. The log resource of the Logging Units was sufficient to permit the saw-millers to install efficient plants and provide comfortable housing for employees. This arrangement has proved of benefit to townships in the region, as increased population has resulted in better services.

For the mill worker and his family it has provided social, educational and recreational facilities previously limited or remote. It has enabled the employer to stabilize his work force by being able to provide better living conditions in relatively remote areas.

The grouping of mills in Conversion Centres has permitted the development of fire protection plans to safeguard settlements from external fires and to isolate fires originating within settlements. The sawmillers undertake to take part in suppression of forest fires and their labour force has played a significant part in these operations.

Contribution of the Timber Industry to East Gippsland and Future Trends

Establishment of the sawmilling industry has resulted in significant development in East Gippsland over the past twenty years. The industry at present employs 688 men in felling, milling and transport of forest produce. Another 70 men are engaged in the sleeper industry, forestry operations employ 65 men and Forests Commission supervision and administration employ an additional 28 men. The income of more than 800 persons, some 15 per cent of the population, is derived from forest utilization, and contributes to the economy of the region.

Sawmillers' housing for employees totals 260 at present and a further 126 huts are available for accommodation of single men. The location of mill employees and families in the small townships has often necessitated improvement of communication, educational and recreational facilities. This improvement has been most marked in Cabbage Tree Creek, Cann River and Club Terrace (See Appendix 1). Although sawmillers provide accommodation for 50 per cent of the work force, this is a lower ratio than was housed fifteen years ago, indicating that some employees have obtained their own homes and have become permanent residents of the region.

Furthermore, logging contractors have obtained undeveloped land and brought it into production, by utilizing their plant for clearing at times when the plant would otherwise be idle.

Additional mills with an allocated log intake of 17 million s.ft H.L.V. are projected for construction at Orbost (1), Combienbar (1), and Cann Valley (3). Total log allocation from the forests of the region will then be 136 million s.ft H.L.V. per annum.

In the procurement of 107 million s.ft of mill logs during the past year sawmillers cut over a total area of 17,200 acres of forest. The yield from each acre was in the order of 6,000 s.ft H.L.V. Although some areas yielded a greater volume, in general there is up to five times this volume remaining in trees not suitable for mill logs. Hence, although portion of the site can be regenerated, this large residue must be removed before the forest area can be brought into full production.

East Gippsland is outside the economic range for supply of the residue to established wood pulp industries, but the wood pulp industries of Japan, together with Australian timber companies are investigating the possibility of obtaining this material for export as chips to Japan. To make this operation economic would require the production of 300,000 tons of chips per year for a period of 10 years. This is the equivalent of logging some 100 million s.ft H.L.V. and would require the employment of at least 300 men during the period. A programme of utilization on this scale would be welcomed to dispose of milling and logging residues and to remove from the forest material not at present marketable. As well as providing substantial silvicultural improvement to the forest, the project could result in further impetus to the economic development of the region.

APPENDIX 1

EXPANSION OF SAWMILL EMPLOYMENT AND HOUSING 1952-1967

	1952—34 Sawmills			1967—43 Sawmills		
	Employees	Accommodation		Employees	Accommodation	
		Houses	Huts		Houses	Huts
Bemm River	—	—	—	30	9	14
Bendoc	33	5	8	57	7	12
(Delegate N.S.W.)	—	—	—	—	7	3
Bonang	15	3	1	13	6	3
Buchan	15	4	3	29	16	6
Cabbage Tree Creek	95	52	24	110	57	7
Cann River	16	2	—	73	42	24
Club Terrace	50	5	9	82	13	30
Combienbar	—	—	—	(Under Construction)		
Gelantipy	12	3	4	16	10	4
Genoa	—	—	—	4	—	—
Goongerah	—	—	—	20	5	8
Maramingo Creek	—	—	—	5	1	—
Martins Creek	7	1	—	—	—	—
Murrungowar	6	2	2	—	—	—
Noorinbee North	—	—	—	8	3	1
Nowa Nowa	38	4	2	79	8	2
(Lakes Entrance)					7	—
Orbost Newmerella	102	40	13	92	63	3
Sardine Creek	—	—	—	25	5	8
Waygara	63	2	10	45	1	1
	452	123	76	688	260	126

9

AGRICULTURE IN EAST GIPPSLAND

By the Late F. R. DRAKE

District Agricultural Officer, Bairnsdale, Victoria

Agriculturally, parts of East Gippsland are some of the least developed in Victoria. I refer to the region E. of Lakes Entrance, including the Shire of Orbost and the greater part of the Shire of Tambo, and it is this region I shall discuss.

The total area is around three million acres, of which 690,000 acres or 23 per cent are described as occupied for agricultural purposes. However, this area includes wide Crown leasehold, much of it timbered and used only for extensive grazing purposes. The area privately owned and used for more or less intensive farming is estimated as being about 400,000 acres, or only 13 per cent of the total.

Much of the terrain is rugged and rough, and most of it heavily timbered. There are, however, some quite large areas of Crown Land which could be developed for agricultural purposes, but at high cost. At the same time alternative land use, such as reserves for forestry, flora and fauna, watershed management and so on, should be given full consideration.

Most of the agricultural settlement is found in two main areas: to the W. a substantial area surrounding Buchan and extending northwards into the higher plateau country including Gelantipy and Wulgulmerang; and the second large area comprising the river flats, coastal plains and adjoining cleared foothills around Orbost.

There are other areas, mainly of river flat and foothill country, scattered from Lakes Entrance to Mallacoota, with a northerly extension along the Cann River, and also more isolated inland settlements at Bendoc, Bonang and along the Deddick River (Tubbut).

Practically all of this country has an average annual rainfall of over 30 inches, except the south west corner near Lakes Entrance and a rain shadow area to the north west, including Wulgulmerang and Tubbut.

Agricultural Activities

These districts support a wide variety of agricultural activities. Grazing predominates and sheep are run for both wool and meat. Beef cattle are run throughout the settled areas and also to a limited extent on Crown leaseholds. Due to high values prevailing over recent years, fewer cattle are now being 'run in the bush'. But, with the progress in pasture improvement, increasing numbers are run on freehold country and cattle are turned off at much younger ages than was the case 20 years ago.

Dairying is largely concentrated around Orbost and Cann River with scattered farms further afield.

Approximate numbers of the different classes of livestock as at 31 March 1966 were:

Dairy cattle	26,500
Beef cattle	35,500
Sheep & Lambs	166,750

If we use a conversion ratio of 8 to 1, cattle run are equivalent to 248,000 sheep. Thus 40 per cent of the feed goes to sheep and 60 per cent to cattle.

I cannot give figures for the particular area, but for East Gippsland as a whole, stock numbers have increased substantially over the last 20 years—e.g. sheep by 73 per cent, dairy cattle by 45 per cent and beef cattle numbers have almost doubled. This indicates an overall general increase of around 75 per cent.

It is important to realize that this expansion is based almost wholly on pasture improvement and not on the bringing in of new land. Pasture improvement has been going on at an accelerating rate in recent years. It depends on the correct use of fertilizers to overcome soil deficiencies, together with the introduction of more productive species and varieties of grasses and clovers.

Soils of the Area

Apart from some very fertile river flat country, e.g. the Snowy River flats at Orbost, most of the soils of the coastal plains and adjoining foothills are of low natural fertility. All are deficient in phosphorus and most of the sandy and gravelly soils show responses to copper and molybdenum. Large areas are at least marginally deficient in copper and this can affect stock health and performance, as well as the growth of pastures.

Most of these soils have low reserves of potassium and after the initial improvement phase has been passed, applications of potash fertilizer are needed to maintain pastures at the highest level of production.

The fertilizer treatment involved is costly but the production of dry matter from a fully improved pasture can be 6 to 10 times that from a native pasture.

Soils of exceptionally low fertility occur on the 'grass tree' (*Xanthorrhoea* spp.) plains which occur quite extensively E. of Marlo. The soil supporting the grass tree association is a strongly acid dark grey sand with much organic matter and with a pronounced organic hard pan at a depth usually between 1 and 2 ft. The 'plains' are usually treeless and have attracted attention because of the assumed low cost of development.

Work carried out in the area showed these soils to have a very high manurial requirement. The following figures indicate the magnitude of the responses obtained on an area cultivated and sown with a pasture mixture in 1953.

TREATMENT	YIELD
No fertilizer	Nil
Superphosphate 5 cwt	3 tons
Super 5 cwt + Agricultural lime 20 cwt	4·9 tons
Super 5 cwt + lime 20 cwt + Muriate of potash 1 cwt	7·8 tons

Fertilizers = cwt per acre; Yields = tons green herbage per acre.

Lime applied broadcast prior to sowing is fundamental to pasture establishment on these soils and adds greatly to the cost. Even when their manurial requirements are fully met pasture growth is limited by bad physical characters. They become water-logged in wet periods and dry out quickly in summer.

Most of the soils in the agriculturally developed inland areas are derived from igneous rocks or limestone deposits. They are of higher fertility, but all respond to phosphate fertilizers and some of the grey basalt soils have shown responses to potassium and molybdenum. However at this stage at least the need to use fertilizers other than superphosphate is unusual.

Of interest is the widespread shortage of sulphur in these inland soils. Sulphur deficient pastures are typically yellow, and clover growth is restricted. While sulphur requirements are adequately supplied by the normal applications of superphosphate, experiments have shown a very poor response to sulphur-free concentrated phosphate fertilizers. These are now being manufactured in Victoria but our work has shown that they should not be used for topdressing pastures in East Gippsland.

Summer Crop Zone

The coastal region has long been known as a summer crop zone. This is based on its mild weather, long frost-free period and relatively high summer incidence of rainfall.

However the actual area devoted to crop is quite small compared with the area under pasture and in 1965/66 was only 6,500 acres—about 1 per cent of the total area occupied. The two principal crops are maize and beans, the proportional amounts grown depending mainly on likely financial returns. At present bean acreage is going up and maize down.

Last summer the area of maize was 900 acres and of beans 2,000 including 1,000 acres green beans for processing, 700 acres for seed and 300 for dry culinary beans. The latter are special varieties which are allowed to mature and are harvested dry. They are used for the grocery trade.

The bean crop has been subject to much loss from disease. This is being overcome by a system of certification of seed from disease-free crops and by spraying for disease control.

Demand for green beans for processing—canning and quick freezing—is rising. Improved husbandry methods including chemical weed control, effective disease control and the wider use of irrigation are resulting in much higher yields. Most crops both dry and green are now machine harvested.

The bean crop is certain to become of greater economic importance but the area of suitable land is limited, and agricultural expansion will continue to depend mainly on development of the pastoral industries.

Future Development

Recent studies have indicated that further doubling of stock numbers on the area already cleared is quite feasible simply by applying present knowledge of pasture improvement methods. I believe first consideration should be given to this method before additional land is cleared.

However further clearing of timbered Crown Lands is certain to proceed and it is important that such development should be done in the most effective and economical way possible.

Experience of Crown Land settlement since the last war has been quite unsatisfactory. Blocks have been allocated to individuals with inadequate knowledge and finance, and the failure rate has been high. Costs are continuing to rise and a high degree of skill and experience is needed for this work.

To investigate costs and methods a pilot farm area of 300 acres of typical medium forest land at Tostaree was developed. The work was directed by a committee representing the Departments of Lands, Agriculture, Forests and Rural Finance and Settlement Commission. Work commenced in 1962 and sowing down to pasture was completed in 1966.

Highly productive pastures were established but the cost was high: around $150 per acre, made up roughly by clearing and burning $100, cultivation $20, seed and fertilizer $15, water supply and fencing $15.

Clearing costs could be reduced by large scale operation and the use of larger machinery, but an all-up cost of less than $120 per acre would be unlikely for similar country.

Adequate finance is therefore needed. The job is no longer one for the simple pioneer, and can be done properly only by a large organization.

Provided land preparation is adequate it cannot be too strongly stressed that correct fertilizer treatment is the key to success. If this treatment is restricted or incorrect the result is an unproductive pasture which soon reverts to fern, tussocks and scrub. This has too often been the result in the past.

If the job cannot be done properly, the land should be left alone until the needed resources are available.

Finally, any further extension of Agriculture in the Region should be approached with scientific detachment.

Conglomerate beds, Woolgulmerang. (*A. W. Howitt, 1876.*)

10

RESOURCES OF EAST GIPPSLAND, VICTORIA
SUMMARY OF SYMPOSIUM

By R. G. DOWNES

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The contributors to the symposium have provided an outline of our knowledge of this part of Victoria, both with respect to the potential of its natural resources and the use being made of them at present. This summary is concerned with how the information may be used to consider what can happen in the future.

A proper basis for the consideration of the future development and use of the resources of a region should recognize certain key axioms.

1. The development of the resources of a region should be considered **in relation to the whole of the resources of the State** and possibly of the Commonwealth. Too often development and use of resources is looked on in a parochial fashion. The local people want something of everything: agriculture, industry, tourism, national parks, and the ancillary developments and advantages of all these activities. Pressures of this kind often lead to mistakes and inefficient overall use of both the region itself and the total resources of a country.

2. Resource development must take into consideration the need of the whole community for **land for different purposes.** People need land for production of food, fibre and water, for industrial and urban development, for transport and communications, for recreation, and land in an unchanged state for scientific study and for the preservation of plant and animal species.

3. The needs of the community for land for different purposes may **change with time**, and some uses thought to be relatively unimportant today could be extremely valuable in the future.

4. Different types of land have different potentials for various uses; the most valuable areas are those which are eminently suitable for a number of uses. These particular areas should be retained under **flexible forms of land-use** so that changes can be made to accommodate changing needs and demands of the community.

5. As far as possible, **multiple land-use should be the objective** so that land is serving the community to its fullest possible extent.

6. Systems of land-use and management should be such that the land will continue to serve its chosen purpose and will not suffer damage or decline in productivity or usefulness. For this reason the **decisions on how land is used should be based on the ecological concept**, that imposed changes on an area of land will

be followed by other reactionary changes. There is a need to ensure that such changes will either maintain stability, or create a new stability, if the continuing usefulness of the area is to be secured.

7. The present community should not make all the decisions for future generations. Unless there is an urgent need for finally deciding the use of an area for specific purposes, there could be considerable advantage in having **areas of land for which the use is at present uncommitted.**

The East Gippsland Region, although one of the earliest to be settled in Victoria, is now one of the least populated and therefore least developed. This situation exists, not because the region is devoid of resources, but rather because of its remoteness from the major centres of population. In considering the possible planned utilization of the region, the basic axioms outlined above must be borne in mind, and at the same time consideration given to the likely needs of the State of Victoria for the use of various resources during the rest of this century.

The development of oil resources and the further development of the industrial complex just to the west of the East Gippsland Region will undoubtedly lead to an increase of population much nearer to the region than the existing metropolis of Melbourne. This could create a different kind of demand on the resources of the region in the following ways.

Agriculture in the region has been handicapped in the past. The great distance from centres of population imposes a high cost for the transport of farming needs such as fertilizers, and for the transport of produce from the region. Centres of population closer to farming areas could not only alleviate this disability, but also create an improved demand for certain high value crops, such as fruit and vegetables, in a market where the economic disadvantage due to distance is much less.

Timber resources can be expected to be subject to much greater utilization because of the demand from closer centres of population, but the availability of resources will need to be studied and their utilization planned in relation to a continuing demand, or in some circumstances as the first stage of development of land for some other purpose.

No mention has been made of the water resources of the region during the Symposium because the area, by comparison with many parts of the State, is well supplied naturally. Nevertheless the development of these resources will need to be integrated with others, to serve the best interests of the community.

The new population centres could create a much greater demand for tourism and recreational land-use and if this is so, there is a splendid opportunity to prevent haphazard development which has occurred in other parts of Victoria, and led to the partial destruction of the land for the purpose for which it is now desired.

The area has unique natural features since the climate is more akin to parts of the South Coast of New South Wales, than to the rest of Victoria. Thus there is a great opportunity to set aside areas representative of the different types of country, for ecological reference and scientific study. These could be important reference areas for judging the soundness of our man-imposed systems of land-use and management.

There appears to be no great urgency for the development of the region, and so it is an appropriate part of Victoria for proper basic studies designed so that relevant information will be available for properly planned development and utilization of the resources as the needs arise.

This presents a marvellous opportunity for a technically able modern society to do the right thing, if only society can be convinced that there is a right way to go about the integrated development of a region. This would be a development other than the day-to-day process of succumbing to individual pressures for this or that use of the land, and the making of unilateral decisions about resource use which so often lead to waste and sometimes destruction of resources, and to economic failure.

Cliff at Maximillian Creek. (*A. W. Howitt, 1876.*)

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1. Papers, in a form suitable for publication and complete, should be sent to the Research Secretary. They should be as concise as possible, and accompanied by a brief abstract.

2. Papers should be typed, double-spaced throughout (including References), with ample margins, and on one side of the paper only. Footnotes are to be avoided. Explanations of Plates and Text-figures, typed double-spaced, should be attached to the MS as final pages.

The use of italics should be restricted to generic and specific names, foreign words, and titles of periodicals and books.

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3. The cost of author's corrections to proof above what the Council considers a reasonable amount shall be borne by the author.

4. **References** should be listed at the end of the paper, arranged alphabetically under authors' names, e.g.

FENNER, C., 1918. The physiography of the Werribee River area. *Proc. Roy. Soc. Vict.* 31: 176-313.

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THE PRESENT STATUS OF THE THEORY OF EVOLUTION

By GEORGE GAYLORD SIMPSON

Harvard University and the University of Arizona, U.S.A.

Lecture delivered on 17 September, 1968, under the joint auspices of the Royal Society of Victoria and the University of Melbourne

Fact, Theory, Philosophy, and Darwin

In order to consider the status of evolutionary theory, it is good first of all to specify what is meant by 'the theory' or, more generally, 'a theory'. Ill-instructed people in the United States—and I find that this is sometimes true also in Australia —have been known to say, 'Evolution is not a fact; it is only a theory'. The intended implication is that a fact is something indubitably true while a theory is a mere guess.

Rigidly tenable definitions of fact and theory are difficult to come by, and their subtleties could be considered at such length as to preclude grappling with our intended subject. For present purposes it suffices to consider facts as things reasonably established by the observations, and in the opinions, of those qualified to judge, and to consider theories not as guesses or second-class facts but as proposed and confidently supported explanations of facts thus defined.

In any discussion of evolution it is wise to hark back to Darwin. In Darwin's triple accomplishment we do find not only exemplifications of fact and theory appropriate for the present discussion but also philosophical implications. In the first place Darwin marshalled observations so great in number and indubitable in validity that they could not reasonably be understood in any light other than that of organic evolution. Thus, by the admittedly somewhat special definition that I am using here, Darwin revealed evolution as a fact. At the same time and without forcing a distinction between the two accomplishments, Darwin proposed an explanation of the observations testifying to that fact. In other words, he advanced a theory of evolution. *The Origin of Species* not only showed that evolution did occur but also considered how and why it occurred; the book comprises both fact and theory.

Beyond fact and theory there is still another consideration: the bearing of fact and theory on our understanding of our lives and of the universe in which we live. This is the proper domain of philosophy. Darwin was not an academic philosopher, not always even a conscious one, but his work revolutionized philosophy as much as it did knowledge of and explanation in biology. In spite of his generally non-philosophic attitude, he perceived that this was true and it struck him with awe. Biology finally entered fully into the *natural* sciences. Life was now to be comprehended in wholly naturalistic terms, and the origin of our own selves became a material event requiring, indeed permitting, no supernaturalistic postulate.

Thus we have as early as 1859, and more dimly even before that, the fact, the theory, and the philosophy of evolution. Henceforth I shall take the fact for granted, and I shall not attempt to expand on the philosophy. The field to be considered here is delimited as the theory of evolution. While we recognize that Darwin laid the sound basis for this field, we also note that he left much to be done. There was ample scope for his successors. Much still remains to be done today, and in turn our successors in evolutionary biology will find—with pleasure, I may say—full opportunity to correct and amplify present knowledge and views.

In this connection it is interesting to consider some of the things which Darwin did not do but about which considerable progress has now been made. Here is a quite incomplete but exemplifying list:

Darwin did not develop a clear concept of what he called 'varieties'. He confused varieties as variant individuals within a population, and varieties as variant populations within a species. The two are quite distinct and have importantly different evolutionary roles.

Oddly enough, in the book called *The Origin of Species* Darwin did not explain the origin of species, not, at least, in the sense usually given to the term 'speciation'. Here, too, a distinction must be made between two quite distinct phenomena. A specific population may change so markedly that it evolves into something different, a new descendant species. Most of Darwin's discussion, and the most successful parts of it, related to that aspect of evolution. On the other hand, a specific population may split into two (or more) distinct and separate populations each of which evolves into a species. That is speciation strictly speaking, or the origin of species in common modern usage. Darwin was aware of this aspect as well, but his grasp of it was less clear and his treatment of it less successful.

In Darwin's day no clear demonstration of evolution in action had been achieved. The nearest approach was in the development of domesticated animals and plants by artificial selection. The analogy was extremely useful and fully exploited by Darwin, but the relationship to the origin of natural species was not yet really quite clear.

Knowledge of the factual history of life, even now very incomplete, was so fragmentary in Darwin's day that he had to devote more attention to explaining its apparent failure to elucidate evolution than to such elucidation.

Darwin's most important and most successful theoretical contribution concerned natural selection. Nevertheless he did not quite achieve a fully generalized concept of natural selection, on one hand, or cover its full range of detail on the other.

Along with virtually all the biologists of his and previous ages, Darwin believed in the inheritance of acquired characters. His general theory was saved by his considering this a comparatively unimportant factor, yet it was a serious flaw in general knowledge of evolution at that time. Neither Darwin nor anyone else in his lifetime correctly identified the sources of organic variation or the nature of heredity.

Heredity

Natural selection requires that individuals within single populations differ, that some of the differences (variations) affect their success in reproduction, and that some such differences be hereditary. Those conditions were understood by Darwin and were known to hold true in natural populations. They suffice to validate the theory of natural selection without knowledge of the origin or nature of variations in heredity. However, it was evident to Darwin and his successors that lack of such knowledge was a serious gap in understanding of the whole evolutionary process. Considerable, although still decidedly incomplete progress in this respect has been one characteristic of 20th century biology.

The basis for such progress is commonly ascribed to Gregor Mendel and dated from his publication in 1865, but such ascription is highly questionable. The actual historical importance of Mendel's work was nil, because in itself it led nowhere.

Its principles were independently discovered some 35 years later and it was the latter discoveries that were effective. Mendel's work was known to his contemporaries, but no one then, and notably not Mendel himself, was able to foresee its possible importance. It probably was not known to Darwin, although this is not quite certain. In any case it would have had little or no significance for Darwinian theory in the context then existing. Mendel devised a quantitative, statistical technique that would much later be instrumental in major advances in genetics. The advance made by Mendel himself with that technique was the discovery that some determinants of heredity are discrete and nonblending even though their effects may be masked by the overriding action of others.

It has commonly been said that the assumption of blending inheritance was a fatal flaw in Darwin's theory of natural selection and that it was corrected by Mendel's discovery. That interpretation involves a whole series of misapprehensions. First, Darwinian selection would operate even if heredity were blending, as long as an appropriate source of new variation existed, and the latter is necessary under any theory of evolution. Second, Darwin did not assume that heredity is truly blending, for his own hypothesis as to heredity, although incorrect, involved discrete genetic elements. Third, Mendel's own work had no influence in this respect because neither Mendel nor anyone else related it to natural selection. Fourth, when in later generations the theory of nonblending inheritance was related to natural selection, it failed to take into account that much of heredity does in fact occur as if it were blending; explanation of that fact was left until still later.

The most important achievement of genetics in the early 20th century was development of the gene theory. The concept of the gene was at first and for some two generations purely operational. The gene was something, of variously guessed but not actually known nature, that does something. The observed something that the unobserved something does is some effect on the development or other functioning of an organism. It was established that many of these effects do depend on material units of some sort, and that most, at least, of such units occur in linear sequence in chromosomes. It was found that they are indeed nonblending and that they can and spontaneously do mutate. Further, their behaviour ruled out the Neo-Lamarckian concept of the inheritance of acquired characters. Inevitably in the early development of gene theory, attention was focused primarily on single genes and single mutations. In fact, even though the genes are discrete, all the elements in the entire genetic system interact. That at last explains why heredity often seems to blend, and it requires consideration of development and evolution in terms much broader and by methods more difficult than those earlier based on single genes.

All those discoveries and inferences provided a thorough genetic underpinning for evolutionary theory. With so much operational knowledge of genetic systems at the appropriate evolutionary levels of individuals, populations, and communities, it actually did not matter much what a gene *is* in precise physico-chemical terms. Nevertheless it was clear that this would be desirable knowledge not only for the biochemist but also for the evolutionist. It would eventually supply a still broader basis for evolutionary theory and still deeper analysis of evolutionary phenomena.

Although identification of individual genes is not yet precise, we do now know in general what chromosomal genes are: they are segments of molecules of deoxyribonucleic acid, or DNA. These remarkable giant molecules have four properties in particular that makes their genetic roles possible:

1. In the appropriate cellular environment they become multiplied; replicas of

themselves are produced. Other cells and other individuals can thus inherit DNA with patterns identical to that in an original or parental cell.

2. Occasionally exact replication at some particular point does not occur; there is then a gene or point or locus mutation. This is a source of new variation in a population. (It is far from being the only source of variation.)

3. DNA molecules incorporate four different chemical bases, which may occur in any proportions and in any sequence. Three of these in succession form a functional unit, called a 'codon'. Four bases taken three at a time can form 64 different combinations, all the possible codons. Since DNA molecules are enormously long, the number of codons in each is great, far into the thousands.

4. With a few possible exceptions, each codon corresponds with or is figuratively a code symbol for an amino acid, and a sequence of codons codes for a molecule composed of amino acids in the same definite sequence, that is, for a particular polypeptide or protein. (The actual control or transfer of information from DNA, usually to a protein acting as an enzyme, is complex and need not concern us here.)

Despite some claims to the contrary, I think it unlikely that chromosomal DNA, constituting the classical genes, contains all the information needed to build and operate an organism. Nevertheless it certainly contains a large and essential part of that information. It is thus legitimate, although figurative, to think of the individual genetic system in the strictest sense as a coded message containing information that is passed on from parent to offspring and from cell to cell. But even if we take that literally, it is only the introduction to a mystery and not the solution.

A code is not a language, and a language is not a message. The messages involved here are extremely long, complex, and precise. The coded sequences are correspondingly extremely improbable, which is a requisite for their maintenance of an enormous amount of information. But chemically, or thermodynamically, each of the 64 possible arrangements of bases in a codon and each of the billions of possible arrangements of codons in a DNA molecule are equally probable. Moreover thermodynamically caused changes of sequence (chemical mutations) tend to destroy any information that may have been coded. In terms of communication theory, they introduce noise. The language of chemistry here is gibberish, and the existence of a complex genetic message cannot possibly be explained at this level. In fact we have to explain not only the origin of the message but also the suppression of purely chemical (or thermodynamic) events that tend constantly to reduce it to gibberish.

Genetics and Evolution

Within the context of this modern knowledge of heredity, evolution may be considered as the origin, modification, and maintenance of genetic messages. The present status of the theory of evolution must be discussed in that light.

The most difficult evolutionary problem, indeed the greatest problem of biology as a whole, is adaptation. Every organism is adapted in structure, physiology, and often behaviour to a particular way of life and to particular environmental factors and associations. That is so obvious in general as to be a banal observation, yet often so intricate in particular as to strike awe. A homely example is always before us: our own hands, obviously *made for* grasping and manipulation. We take them for granted, but they are so complex that they have never been completely described chemically, anatomically, and functionally. Among literally millions of other examples are such mutualisms as the adaptations of yucca plants and yucca moths, the plants requiring the moths for their pollination and propagation, the moths requiring the plants for the development of their eggs and nourishment of their larvae, plants and animals so constructed and in some sense programmed that they not only can but also must carry out these functions.

For adaptations to evolve there must have been some kind of feedback between organism and environment. (The environment of an organism includes other organisms.) Although the term 'feedback' is new, the idea is old, and this feedback was long and often sought in interaction of individual and environment. That has been considered the Lamarckian error, although to do him justice Lamarck did not fall so far into it as did the Neo-Lamarckians, and to do them justice they ignored a still deeper, quite different error into which Lamarck did fall. A too often neglected fact should be obvious: individuals do not evolve. Only populations evolve. The feedback must be in the population, not in the individual. The Neo-Lamarckians hypothesized a transfer of feedback from individual to population, but they were wrong, as recent genetical knowledge makes final. Darwin correctly placed the whole feedback in the population and discovered its basic mechanism. That was his greatest accomplishment.

Now to follow this up we must think not, or not only, in terms of the individual but in terms of populations. The relevant origins, changes, and preservations are those of gene pools, or better of genetic pools, the sum totals of genetic elements in populations. The following are the causes and kinds of changes that occur in genetic pools:

1. MUTATION. Point mutation, now construed as substitution of one base for another in chromosomal DNA, has been mentioned. More broadly, mutation can also be taken to include such other events as duplications, elisions, or reversals of base sequences or genes or changes in numbers of chromosomes, although mutation in this sense is less clearly distinct in principle from recombination. The essential feature of mutations is that they introduce distinctly new variants into a genetic pool.

2. RECOMBINATION. Sexual and parasexual processes, usual although not quite universal in organisms, constantly produce new combinations of genetic factors already present in a population. Different combinations of genes within a chromosome, sometimes similar to mutations in effects, arise from crossing-over. Reduction of chromosomes from diploid to haploid sets in meiosis produces stochastic, generally new haploid combinations. Fertilization similarly produces stochastic, generally new diploid combinations. These processes, in themselves, do not change the natures or frequencies of genes in a genetic pool, but they produce prodigious numbers of variant combinations of those genes and hence of variant individuals in a population.

3. GENETIC MIGRATION. Sexual and parasexual processes may also involve transfer of genes, or more broadly of any genetic factors, from one population to another. In the recipient population that generally involves introduction of new genetic factors, analogous to mutation, or rise of new combinations of such factors, another kind of recombination, or both.

4. SAMPLING ERRORS. This somewhat equivocal term, borrowed from statistical theory, is used to express the fact that even if other things are equal a descendant population generally tends to have frequencies of genetic factors somewhat different from the frequences in ancestral populations. This phenomenon reaches an extreme when a new population arises from a small number, perhaps only one or two individuals from an ancestral population, for example by dispersal to an isolated island. The founders of the new population certainly will not carry all the ancestral population's genetic combinations and almost certainly not all its gene alleles. At the other

extreme, in a continuously large and fairly panmictic population gene frequencies usually tend to fluctuate but little around a stable mean.

5. Natural Selection. This factor will be defined and discussed in the next section.

The first three of those five influences changing genetic pools tend to maintain or to increase variation in populations. The fourth commonly tends to decrease variation temporarily. All are important factors in evolution. Indeed, in combination, they are absolute requisites if evolution is to occur at all, for they provide the materials and the basis for evolutionary change. However, none of them is oriented with respect to adaptation. Although not random in an absolute or unlimited sense, they are random or stochastic in the sense of having no connection, in themselves, with origin or maintenance of adaptations. None of them is oriented by feedback from the organism-environment interaction. Evolution under their influence alone would involve adaptation by chance. But adaptations of organisms are so universal and so intricate that their origin or maintenance by chance would be enormously improbable, improbable quite to the point of utter impossibility. There must, then, be a fifth factor that is correlated with adaptation, that does include organism-environment feedback, and that provides an antichance element in the orientation of evolution. That factor is natural selection.

Natural Selection

Once Darwin had pointed it out, the reality of natural selection became obvious. It followed unquestionably from a concatenation of facts none of which can be seriously doubted:

Natural populations tend to produce more offspring than survive to maturity.
Individuals in a population differ.
Some of their differences are hereditary.
Some hereditary differences affect survival.

Therefore such differences as promote survival will tend to accumulate in a population.

Put in just that way, the principle of natural selection is indubitable, but it is limited in scope and significance. There was considerable force in the criticism that Darwinian selection, with its emphasis on survival in the struggle for existence, was primarily negative and accounted rather for the elimination than for the origin of organic characteristics. Darwin himself did take a broader view, and this has been adopted and greatly clarified since his day. He wrote, 'I use the term struggle for existence in a large and metaphorical sense, including dependence of one being on another, and including (which is more important) not only the life of the individual but success in leaving progeny'.

At present 'success in leaving progeny' is not merely included in the principle of natural selection. It is the whole point. For precision, the following conditions must be made further explicit: the success in question is relative or comparative either within a single population or as between two interacting populations; it involves an average over a considerable period of time in terms of generations of the organisms involved; and the success must have a positive correlation (however slight) with a genetic factor or combination of factors. With those conditions understood, natural selection is defined as *genetically differential reproduction.*

For any given kind of organism a vast number of conditions both external and internal can influence reproduction and thus can have a bearing, positive or negative, on natural selection. The direct influence generally takes one of three forms.

First is mortality, or, conversely, survival selection, which acts by genetically differential failure of individuals to survive through the whole reproductive period. That is the most obvious form of selection and was most emphasized by Darwin and his immediate followers. Second, and in many species at least equally important, is fecundity selection, genetically differential success in leaving descendants. This is a populational phenomenon and is to be measured not within reproductive units in single generations but in populations over periods of several generations. It is also noteworthy that fecundity selection can be influenced, mostly among highly socialized animals, by members of a population that are not themselves actively reproducing, as by workers among ants or helpful grandparents among humans. A third relatively little emphasized form of selection is by age of parenthood. Within a population, parents that begin reproducing at an earlier age will tend to have more descendants at any given time thereafter than parents that begin late. This effect is generally not obvious, because it is often cancelled out by mortality selection or masked by the greater effect of fecundity selection.

Natural selection may further be seen to operate at different biological levels. Action most directly at molecular and nuclear levels is for the most part elimination of gross abnormalities, hence negative and little involved in positive adaptation or evolutionary change. Usual positive action directly involves the phenotype as a whole, and hence indirectly the genetic system as a whole. To think of selection as acting on single genes or to rely on mathematical models so based, as was usual in earlier stages of population genetics, is usually unrealistic. At the organismal and populational levels involved in usual selection, its effects can rarely relate to a single gene. Even at the level of the genes themselves relevant selection rarely acts separately on one gene. Genes are discrete but not isolated; their actions are balanced and integrated by complex interactions. That is true within individuals. In the population, where adaptive feedback occurs, there are further complications. No attempt can here be made to summarize knowledge of these, but a striking example may be mentioned: balanced polymorphism. In this phenomenon, which now appears to be rather widespread, individuals heterozygous at a particular gene locus are selectively favored over homozygous individuals. Because a heterozygous population necessarily produces a certain percentage of homozygous offspring, positive selection on the population in such cases is itself productive of individuals subject to negative selection.

Some misapprehensions about natural selection linger on from Darwin's day, although Darwin himself did not share all of them. One that he sought to correct and yet fostered by the phrase 'survival of the fittest' is that natural selection tends in the direction of individual superiority, of increasing fitness in the vernacular sense. In fact it tends only toward relative success in reproduction. Geneticists have confused the issue by defining fitness as such success, which makes selection as 'survival of the fittest' a banal tautology. It is usually true that fitness in the nontechnical sense of individual adaptation does make for relative success in reproduction of the population. That is why and how natural selection does cause adaptation, but the relationship is indirect and is not invariable.

The same point is further involved in some obscurity in the distinction between natural and artificial selection, another thing not yet absolutely clear in Darwin's pioneering studies. The essential difference is not just that one occurs in nature and the other is conducted by man, but that the sole direct effect of natural selection is a relative reproductive differential under existing conditions while the purpose, and, if successful, result of artificial selection is change in any characteristic other than reproductive differential. Many experiments on selection do not involve natural selection, because that differential is controlled by the experimenter and not by the experiment. (Such experiments may nevertheless produce genetic information useful in consideration of natural selection and other factors of evolution.) It often happens in plant and animal breeding that natural selection, which occurs willy-nilly in such artificial procedures and not only in nature, eventually runs counter to artificial selection and limits or ends the breeder's progress.

Another point that has required and received clarification since Darwin is the relationship between natural selection and sexual selection. Years elapsed between Darwin's publication of *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (the full title of his most famous book, first edition in 1859) and that of *The Descent of Man and Selection in Relation to Sex* (1871). It was not merely incidental that the latter book, in which Darwin first overtly discussed human evolution, also included the apparently distinct topic of sexual selection among animals in general. Darwin believed that natural selection favored the fittest as the best adapted. However, he was persuaded that differences among human races are not in themselves adaptive. Hence if an evolutionary explanation was to be given for the origin of those races, he believed that some directive factor other than 'the survival of the fittest', or natural selection in that sense, was needed. That difficulty was probably among the complicated and diverse reasons why Darwin was among the tardiest of the Darwinists to apply his theories to human evolution.

Darwin's proposed solution was that among humans and some other animals, choice is involved in mating and consequent production of offspring. Some individuals appeal more to the eyes (or ears or noses) of members of the opposite sex. They therefore have greater chances of leaving descendants, and their heritable characteristics, although not adaptive in relationship to the environment, will selectively increase in the population. This phenomenon does occur, but it is now considered less general or important and is viewed somewhat differently. For one thing, Darwin's premise has become dubious. It is now believed that many racial characteristics, possibly the majority or even (but somewhat unlikely) all of them are in fact adaptive to regional environmental conditions, taking 'environment' in a broad sense. (In the case of human races, their members no longer live under the conditions to which the races originally became adapted, and determination of the exact nature of the adaptation is correspondingly more difficult.) Further, when sexual selection does occur, its effect is to produce a genetic differential in reproduction within a population, in other words, natural selection. It therefore is not an alternative but simply a special case of natural selection, or one of the very large and varied body of factors that can lead to natural selection under particular conditions.

It is still arguable whether nonadaptive characters arise and persist in the course of evolution, that is, whether variants completely neutral with respect to natural selection occur and continue to lack any selective significance. Oddly enough, it is more likely and is easier to explain that inadaptive characters are involved, that is, that characters adverse or negative to natural selection nevertheless do arise and persist. Definition of that phenomenon depends, however, on taking an unduly narrow view of the whole phenomenon. Such characters are inadaptive only if they are considered in isolation and in a defined and static environmental situation. In balanced polymorphism, previously mentioned, the homozygotes are inadaptive, but they are a necessary outcome of a genetic situation that is over-all adaptive for the population through its production of heterozygotes. More generally, an individual genetic system may have both adaptive and inadaptive, selectively both positive and negative, phenotypic correlates, and selection will act on the algebraic sum of those correlates, not on each adaptive and inadaptive character separately. If the selective balance is positive, selection will develop or maintain the system even if it includes inadaptive phenotypic characters.

It is further important that maximum adaptation to a fully specified, static environmental situation has a poor evolutionary prognosis. Such adaptation would be equal for all individuals, with minimal or no genetic variation in the population. But no environment is in fact stable in all its details, and change in genetic adaptation can occur only on the basis of pre-existing variation. Thus the idea once held that species normally have a particular 'wild type' representing optimal adaptations for any and all individuals is not valid from the more significant point of view of populations. The optimum for continued existence of a species is almost always a variable and relatively labile population. There is a fact highly pertinent here that is not always sufficiently taken into account by nonpalaeontological evolutionists and that would not have been guessed if the fossil record had not revealed it. The vast majority of species in the history of life have become extinct, extinct by termination without issue and not in the purely nominal sense of extinction by conversion into a new, different species. Here is a vital paradox: natural selection, a process requisite for survival of species, has extinction, non-survival, as its *usual* outcome.

Finally in this extremely summary treatment of natural selection, reference may be made to the previous observation that evolution requires the suppression of purely chemical or thermodynamic events in the genetic system. If strictly chemical processes at the individual and molecular level had, so to speak, been given their head, not merely the majority but the totality of organisms would now be extinct. The answer is again natural selection. Survival of lineages of organisms through geologically significant spans of time demands a measure of adaptive lability, dependent on genetic variability. Nevertheless the overall adaptation of the lineage as a species at any one time requires considerable uniformity in its members. It is usual that extreme phenotypic variants are more subject to early mortality and less fecund than those nearer the population mode, which is therefore usually favored by natural selection. In this role natural selection is a centripetally directional force or a stabilizing or homeostatic mechanism, tending to conserve the existing adaptation of a population, to counteract adaptively unoriented influences such as mutation, and to damp out stochastic fluctuations of the genetic pool. When directional change is occurring under the influence of natural selection, the most extreme variants, even those in the direction of that change, are commonly at a selective disadvantage. Thus the rate of change is moderated by simultaneous stabilizing selection, and the trend is self-braking. The fossil record is replete with examples of long, slow trends. In laboratory experiments with stabilizing selection artificially eliminated, similar changes can be produced at rates sometimes literally millions of times faster. In nature the most common and strongest effect of selection is not for change but for evolutionary homeostasis.

Speciation

Study of the origin of species, taken literally and not so broadly as by Darwin, has involved especially two primary problems and a multitude of secondary ones. There is not time here to discuss any of the secondary problems, interesting and important as they are, but a few words can be devoted to each primary problem.

The first problem is whether evolutionary change, and particularly such change as results in what are recognized as new species, occurs in single steps, by saltation in a term now somewhat old-fashioned, or gradually. Darwin recognized the existence of saltations, now considered mutations of quite diverse sorts, but held that they are relatively unimportant for the origin of species. He believed that all kinds of evolutionary changes are usually gradual. Discovery that genes are discrete units and that mutations in the broadest sense are discrete events persuaded many early geneticists that such evolutionary events as the origin of species are also normally discontinuous, or occur by noticeably separate steps. That is true in a minority of cases, especially by mutational alterations in chromosome numbers, common only in plants and apparently important only at relatively low levels of evolutionary change.

Beyond that, better knowledge of genotypic and phenotypic variation and abandonment of typological in favor of populational concepts have put the subject on a different and sounder basis. The greater part of phenotypic variation on which natural selection acts occurs in such numerous and small steps as to be effectively continuous. Although completely without knowledge of the molecular substrate, Darwin was right that the usual materials for evolution are small variations. Moreover, regardless of the size of steps possibly involved, the process of change is now seen to be gradual in populational terms when it occurs by shift of parameters of variants in a single continuing biological population and not by instantaneous emergence of a new 'type' outside the parental 'type'. By far the most common course of evolutionary change is gradual in the present sense, and again Darwin's gradualism was correct although he expressed it in different terms and necessarily with less understanding in depth.

The second primary problem for brief consideration here is that of the origin of species in the sense of the splitting of a lineage into two or more. I have already noted that this is one of the few subjects on which Darwin was obscure and confusing. Clarification has come especially from realization that the crucial event is strong limitation or cessation of interbreeding between segments of a population and that such reproductive isolation is generally a cause, not a result, of genetic and phenetic divergence. It has further been determined that such isolation does not normally arise between fully contiguous parts of a population. The usual antecedent is geographic separation, and different species from one ancestral population generally arise in different regions, that is, allopatrically. There are probable exceptions to that rule, and the extent and nature of such exceptions are still subject to debate, sometimes rather heated but of no great importance for the present summary.

A segment of a population that has become geographically segregated does not become a new species *ipso facto* and forthwith. Gradual divergence will inevitably occur if segregation is long-continued. Since this process is gradual, there is no exact point at which the distinction can be unequivocally called specific. In principle, speciation has occurred when the two groups will not interbreed or will do so only to quite limited extent even if they come into contact. In many cases nature has supplied this criterion, but in others its probability must be judged on indirect evidence, especially by the degree of anatomical, physiological, and behavioural divergence. Impediments to interbreeding of groups otherwise in contact with each other are called isolating mechanisms. They are astonishingly varied, and a great deal of ingenious and fascinating research has been devoted to them, especially among vertebrates in which complex behavior is often involved, and among insects. Speciation is finally and irrevocably complete when production of fertile hybrid offspring has become genetically impossible. That stage is finally reached if the relevant populations survive for any great length of time. In spite of the existence of many interspecific hybrids, they are exceptional, and most natural species are completely isolated genetically.

Some Other Aspects

In considering the present status of the theory of evolution I have dwelt on just a few of the subject's most important aspects. It is further characteristic of the present status that theoretical and other study of evolution is now even more widespread, its aspects even more diverse than ever. In the remaining time I can only exemplify and not exhaustively list other aspects, and the examples can only be mentioned and not amply discussed.

The study of evolution as history, of the actual course followed in the descent and diversification of organisms on earth, has progressed enormously since Darwin's day and is now most energetically pursued. In Australia, for example, where really active students of the subject could have been counted on the fingers of one hand a generation ago, there are now programmes carried out from each capital city and in most of the museums and the increasingly numerous universities. The total effort throughout the world is much more complex and significant than the gathering of primary historical data, intensive and essential as that is. Three major steps or activities are involved:

1. Acquisition of Data. These and their interpretations are of two kinds, sequential and comparative. Sequential data, provided by fossils and their living successors, show faunal, floral, and phylogenetic changes on a direct time scale. Comparative data, derived from both fossil and recent organisms but mainly the latter and without applicability of a definite time scale, permit inferences as to evolutionary sequences not directly observable as such.

2. Study of Evolutionary Processes. The processes that act through history and produce evolution are not themselves historical in nature. They are (or at least are postulated to be) immanent features of the universe, unchanging themselves while they cause or influence changes in material organisms. These processes include and are well exemplified by natural selection and speciation, previously discussed.

3. Confrontation of the Preceding Two Aspects of Study. This is the most important theoretical aspect of the historical study of evolution. It includes the explanation of historical events in terms of known explanatory (that is, theoretical immanent) processes, and on the other hand it checks hypotheses about processes against factual historical data.

In the course of historical and other theoretical studies, many particular kinds of evolutionary change have been specified, described, and at least partially explained. For example there are the related phenomena variously discussed under such terms as 'ecological incompatibility', 'displacement', 'Gause's principle', and others. The principle is that if two sympatric populations compete for any environmental resource that could be wholly utilized by one of them, it will happen either (1) that one population becomes extinct at least in the area of sympatry, or (2) that the populations will evolve in such ways as to make them ecologically more distinct and less competitive. This happens to be an example, by no means unique, of a principle already well-known to Darwin and clearly stated by him but several times 'discovered' and renamed in recent years. Recent discussion has, indeed, supplied better knowledge, experimental evidence, and more complete explanation of the phenomenon. That is also true, for example, of the principle that individual adaptability can be selectively replaced by genetic adaptation. That was stated by Baldwin and others in the 1890's, but recent 'discovery' has been accompanied by embryological and genetical explanation not earlier possible.

In other instances, mimicry for example, recent students have been well aware that the phenomena were well known in the 19th century but have contributed greatly in the way of new data and extended explanations. It must not be thought, however, that all recent discoveries are merely rediscoveries or that recent study only exemplifies knowledge of principles already known. Genetic homeostasis, mentioned previously, is one of many examples of principles discovery of which is in fact recent.

As evolution is pervasive and involved in all biological phenomena, it follows that all developments in the science of biology have a bearing on evolution. This review will be closed with two exemplifications of that fact, one having to do with developments in methodology and instrumentation, the other with advance in highly specialized knowledge. The first example involves the fact that biology has shared in the increasing quantification of all sciences and availability of electronic computers capable of rapid processing of enormous bodies of quantitative data. Many evolutionary studies cannot usefully be approached in those ways, but many can be and are being. Mathematical models of selective processes and of their interplay with stochastic factors can now be made much more complex and in that respect much more realistic. The zoogeography of islands can be studied with sophisticated quantitative methods taking into account such factors as area, width of barrier, source fauna, ecological diversity, and others. Phenetic similarity among organisms can be represented by measures involving large numbers of characters. It should perhaps be added in a cautionary way that all these and other computer methods, useful as they are, provide only manipulations of data. At one end, specification of the manipulations to be used, and at the other end interpretations and theoretical conclusions still have to be supplied by hand, or rather by human brain.

Finally, it is noted with utmost brevity that the present activity in the field of molecular biology is potentially of great evolutionary interest and value. The rapprochement of molecular and evolutionary biology, fields that were formerly sometimes considered quite distinct or even antagonistic, is now being actively pursued from both sides. There is still considerable misunderstanding and the results so far are relatively few and preliminary, but this is certainly one of the most interesting and probably one of the most promising developments in modern biology.

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PROBLEMS IN SAMPLING THE ORIENTATION OF FOSSILS IN A GRAPTOLITE BAND AT EAGLEHAWK, VICTORIA

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Abstract

Orientation studies of horizontal didymograptids, pendent tetragraptids, and of phyllocarid carapaces from four successive bedding planes in a shale bed from the railway cutting at Eaglehawk reveal random distributions as well as highly significantly directed ones. Directed orientations give way to random distributions from base to top of the bed for the three types of fossils studied.

Most significantly orientated were the didymograptids and the phyllocarids. Only those pendent tetragraptids with narrow stipe divergence were orientated significantly, suggesting that they were more sensitive to the current. The phyllocarids and pendent tetragraptids indicate a SE. or SSE. source, whilst the horizontal didymograptids were more meridionally aligned towards the top of the bed.

The question of sampling by several forms from one bedding plane, or by one form from several bedding planes to gain an estimate of the current direction at the locality, is discussed. The value of selecting the more elongate, or longest forms to obtain the most significant orientation pattern for all forms is demonstrated.

Introduction

The parallelism of graptolite rhabdosomes has been noticed on several previous visits to fossil localities of the Bendigo district. The Eaglehawk railway cutting terminating Parsonage Grove, south of the Bendigo tramline provides such a locality, where fossils are abundant. The six-inch shale bed is overlain by arenites which exhibit small-scale current bedding from a SE. source. Washout structures in sandstone filled with granule arenite occur in the creek drain, east of the new swimming-pool and lake reserve at Eaglehawk, also suggesting a southeasterly source for the emplacement of the arenites.

The purpose of this study was to determine whether or not the parallelism of the rhabdosomes was consistent with these directional structures; whether the same direction could be inferred from more than one bedding plane, from a combination of bedding planes, and from more than one form.

Method

An orientated slab, with the strike (N10°W) and dip (75°E) direction and magnitudes, in addition to base and top clearly marked thereon, was removed from the outcrop. A sheet of clear plastic could then be placed over the bedding plane, so that reference and rhabdosome lengths and directions could be traced on it with marking inks. The plastic sheet was then removed from the slab, superposed and suitably orientated on graph paper, so that photostat copies of the combination could be obtained from a Rank-Xerox copier for reference. Length and direction measurements could then be made from the photostat.

Rosettes on a 15° or 20° semi-circular or circular distribution could be constructed for bedding planes from the base, lower-middle, upper-middle and top of the 6-inch shale band. Fossils were classified hydrodynamically into the following three categories:

(i) horizontal short and extensiform didymograptids;
(ii) pendent tetragraptids;
(iii) phyllocarid carapaces.

Chi-square tests of significance for each rosette were made for a random hypothesis. Significance at the various levels was read from a set of statistical tables as Krumbein and Pettijohn (1965, pp. 418-420).

Modes of directed distributions were calculated by an algorithm outlined by Whittaker and Robinson (1962, p. 270), or by Schwarzacher (1963). The first harmonic only was considered. Initially in Figs. 1 and 2, the sense of orientation of the rhabdosome was ignored for didymograptids and phyllocarids, so that the distributions were semicircular in that class intervals were in the range of 0 and 180°. Thus the distributions in these were symmetrical, whereas the pendent tetragraptids were scored in classes between 0 and 360°, since their asymmetry dictated a proximal and distal end to the rhabdosome as regards the current sense. Even so, in spite of the asymmetry of the distribution, it is possible to detect in the rosettes of the pendent forms an approximate axis of symmetry which corresponds to the current direction.

Previous Work

R. Ruedemann (1897) noted the parallel orientation of graptolite rhabdosomes, sponge spicules, bryozoan fragments, and straight cephalopods in the Utica Shale. The apices of the cephalopods and the siculae of the graptolites pointed eastwards, from which was inferred an ENE. current.

H. Hundt (1938) ascribed parallel graptolites to the effects of bottom currents. D. Krinsley (1960) presented a rosette for the orientation of 106 orthoceracone cephalopods on a single bed at Lemont, Illinois. As the primary or *a*-mode was from 290°, and the secondary or *b*-mode was normal to it, a WNW. source was inferred. A *b*-mode transverse to the current direction is to be expected if the lengths of the orthoceracones varied, or if the current varied in intensity and direction during deposition, or if reworking occurred after deposition. The shorter particles can be fickle to turbulence while the longer forms are less likely to be turned from their orientation, in virtue of their inertia.

Skwarko (1962) ascribed the orientation of diplograptids at Cobb River in New Zealand to tectonic deformation. W. Schwarzacher (1963) presented rosettes of crinoid stems from many localities to deduce a current pattern in the Carboniferous limestone of the Benbulbin area, Sligo County, Ireland. He demonstrated that a unidirectional current could produce a polymodal rosette, depending on the prevailing current conditions at the time. When there were more harmonics present, more sub-maxima developed.

Ager (1963) demonstrated the behaviour of the orientation of belemnite guards in relation to size. Guards less than an inch long pointed in the opposite sense to those longer.

Theory of Orientation Modes

Orientation modes, whether circular or semi-circular, usually present two directions of symmetry or approximate symmetry, which may be perpendicular to each other. One is the current direction, the other is transverse to it. The problem is to identify the dominant or *a*-mode of the rosette with the current direction or with the normal to it.

By experiment, Schwarzacher (1963, p. 584), was able to demonstrate with crinoid stems that where the current was fast, the *a*-direction bisected the acute angle between the two prominent complementary modes. Where the current was slow, the current direction bisected the obtuse angles between the modes.

The liquid impact I on a particle is the product of the square of the speed of the current, v, and the area A_n of the particle which is normal to the current. Thus, for an elliptical plate (which might simulate a phyllocarid carapace) of semi-major and semi-minor diameters a, b respectively, aligned at angle θ to the direction of the current of velocity v,

$$I = kv^2 A_n \qquad (1)$$

where k is a constant depending on the environment.

$$\text{Thus, } I = kv^2 \pi ab \, . \sin\theta$$

$$\text{or} \qquad \sin\theta = \frac{I}{\pi kv^2 ab} \qquad (2)$$

If I is to remain constant, and v is a maximum, then $\sin\theta$ will tend to be small. This means that the elliptical plate tends to align itself with its long axis parallel to the current. With decrease of speed, $\sin\theta$ tends to enlarge, so that the plate tends to lie transverse with the current, with an accompanying increase in randomness of the modes.

Results

1. NATURE OF THE POPULATION

The composition of fossil forms from the four bedding planes sampled at Eaglehawk is given in Table 1.

The most abundant forms are *Tetragraptus fruticosus* (3-branched form), horizontal didymograptids, and oval phyllocarid carapaces. These thus formed the basis of the orientation study, but sufficient forms of *Tetragraptus pendens, Didymograptus dilatans*, and *D. similis* were available for outcrop study by cumulating all four samples. A minimum of 12 samples was required for a 15° class, semi-circular distribution, or for a 30°, circular distribution.

2. SAMPLING BY BEDDING PLANES

Bedding plane 1, the basal representative, is shown in Fig. 1A, B. Fig. 1A shows the 15°, semi-circular distribution for horizontal didymograptids. The orientation of the stipes is plotted against the frequency for the midpoint of each 15° of arc. No provision was made for the position of the sicula or thecae on each rhabdosome. Thus the 15° midpoint shows two stipes aligned between N.7½°E. and N.22½°E. but whose thecae could be facing either NW. or SE. The current direction for the rosette is inferred as the bisector of the acute angle between the primary modes rather than the obtuse angle bisector, in the light of the distribution of Fig. 1B, and the SE. current bedding in the arenites overlying this shale band.

Fig. 1B is a 20°, circular distribution for the combination of *Tetragraptus fruticosus* (3 Br.) and *T. pendens* specimens. The rosette clearly shows a SSE. source, with most of the proximal portions of the of the rhabdosomes being directed up-current. Unit circles for figures of rosettes are unlabelled, and unless otherwise specified, indicate one observation per unit increase in radius.

Fig. 3 is a line graph plotting the significant difference from random orientation as determined by chi squared for 11 degrees of freedom, for the three distributions for each bedding plane as portrayed in Figs. 1 and 2.

TABLE I

Analysis of Fossil Forms from the Four Bedding Planes scored for Orientation Studies, Railway Cutting, Parsonage Grove, Eaglehawk

Fossil Forms	Frequency:	No. per 100	
PENDANT TETRAGRAPTIDS:			47
	T. fruticosus (3 Br.)	35	
	T. pendens.	9	
	T. pendent sp. indet.	3	
OTHER TETRAGRAPTIDS:			4
	T. serra	4	
HORIZONTAL DIDYMOGRAPTIDS: (inc. *D. abnormis, D. ensjoensis, D. similis*)			25
OTHER DIDYMOGRAPTIDS:			8
	D. dilatans	5	
	D. hemicyclus	3	
OTHER ANISOGRAPTIDS:			4
	Phyllograptus sp.	1	
	Multiramous forms (esp. *Goniograptus macer*)	3	
PHYLLOCARID CARAPACES			12

In the case of the 18-class, 20° sector for tetragraptids, conversion was made to 11 degrees of freedom from the formula:

$$\chi^2_{11} = \frac{11\,\chi^2_{17}}{17} \tag{3}$$

This has allowed some comparison of relative significance of all three orientation patterns on the one diagram. The line graphs of Fig. 3A show that all the tetragraptid distributions were random, all the phyllocarid distributions were directed, and that the lower middle and upper didymograptid distributions were random. The lower set of line graphs shows most divergence of directional modes in the middle of the bed, and closer agreement between tetragraptids and phyllocarid directions, the mean direction of all forms being southerly.

DISCUSSION

Fig. 1C, D, E shows the orientation patterns from the lower middle bedding plane. Both didymograptids and tetragraptids fall below the level required for significant directed orientation, but rosettes suggest a southerly current source. Phyllocarids are more strongly directed with a SSE. mode. The configuration of of the modes suggests a decline in current strength for the didymograptids and tetragraptids, which is confirmed by the random orientation of the rosettes as a whole. The tetragraptids in this sample were shorter in length when compared with those of Fig. 1B. Equation (2) suggested that shorter rhabdosomes would lie more transverse with the current, since sin θ is inversely proportional to a, the long dimension. Thus Fig. 1D tends to approach the butterfly-like *b*-pattern of Schwarzacher (1963, p. 581, Fig. 1; p. 584, Fig. 4B), but with the proximal portions tending to point up-current. The difference in direction of the rosettes of didymograptids and tetragraptids from the phyllocarids could be explained in

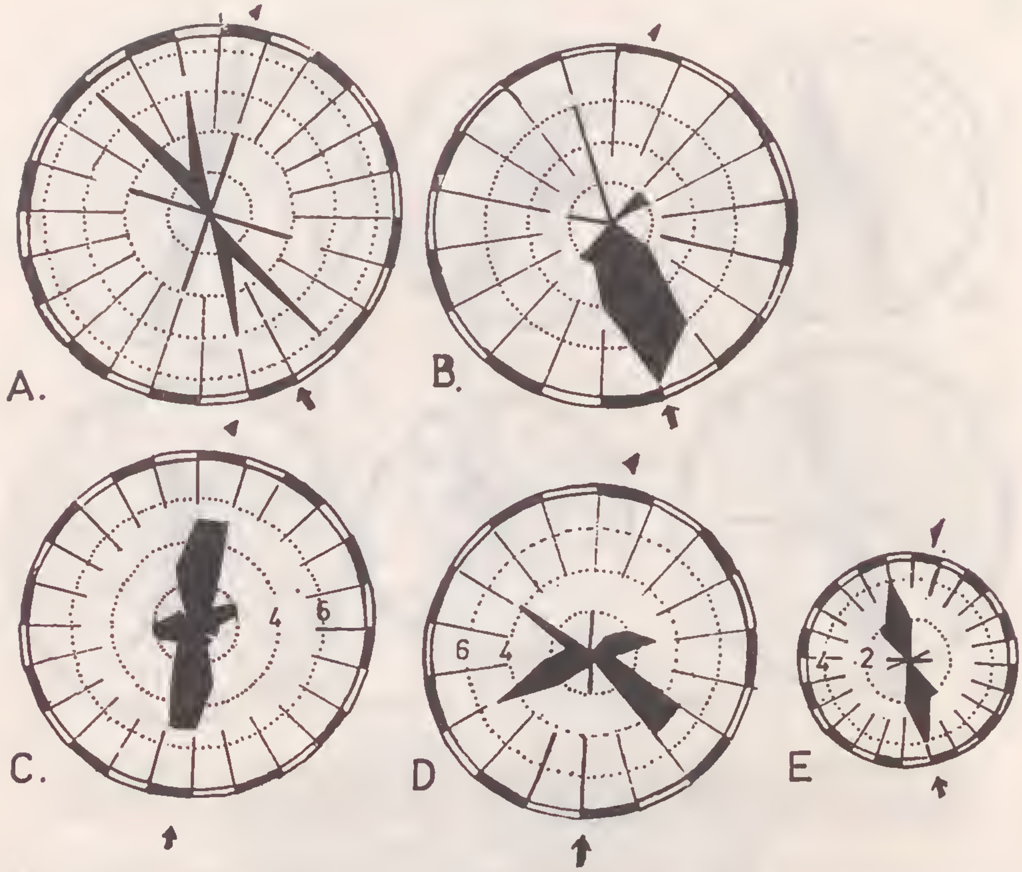

FIG. 1—Orientation distributions of fossils from the basal pair of bedding planes at Eaglehawk. A, B—Basal Plane 1; C, D, E—Lower Middle Plane 2; A, C—Horizontal didymograptid rhabdosomes (15° semi-circular distributions); B, D—Pendent tetragraptids (20° circular distributions); E—Phyllocarid carapaces (15° semi-circular distribution).

terms of the former two groups being pelagic, and settling in more gravitationally directed trajectories through the water, whilst the phyllocarids could have been brought in by a stronger SSE. current operating close to the ocean bed.

Fig. 2A, B, C shows the three corresponding distributions for the upper middle bedding plane. Pendent tetragraptids are even more random, but rosettes for didymograptids and phyllocarids are highly significantly directed, from SSW. and SSE. respectively. If any directional mode can be attached to Fig. 2B it would be from the SSE., but there is also a SSW. secondary mode. It is suggested that the pelagic tetragraptids were realigned by later currents which brought in didymograptids from the SSW. and SSE. in separate phases. The bedding plane records fossil forms which suggest multidepositional events during which there could have been winnowing and realigning of already deposited forms.

Fig. 2D, E, F shows a decline in significant directional properties with respect to the upper middle bedding plane. The return of the phyllocarids and didymo-

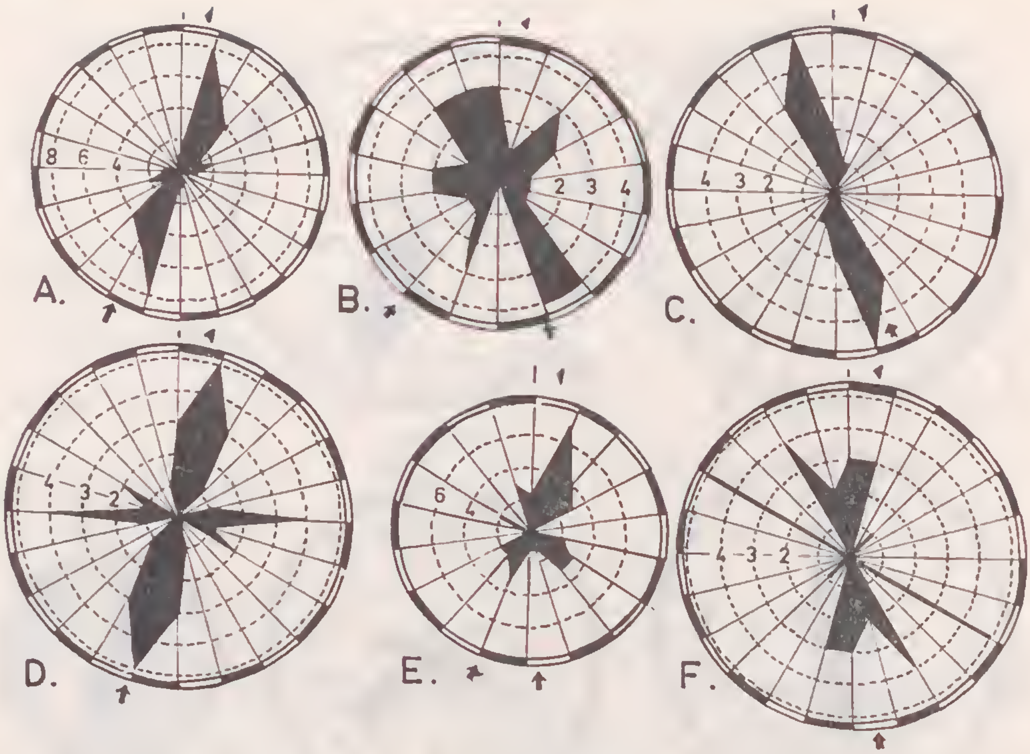

FIG. 2—Inferred directions for the orientation distributions from the upper pair of bedding planes at Eaglehawk. A, B, C—Upper Middle Plane 3; D, E, F—Uppermost Plane 4; A, D—Horizontal didymograptids; B. E—Pendent tetragraptids; C, F—Phyllocarids.

graptids to random orientation to different degrees suggests weaker currents and a return to a more southerly source. If the relative strengths of the two different currents recorded in Fig. 2A-C are reflected in Fig. 2E, then the SSW. current could have been responsible for the alignment of the tetragraptids in the NNE. mode, and perhaps the transverse mode in the phyllocarid rosette. Both of these modes could have been the product of realignment of tetragraptids and phyllocarids when the SSE. current persisted into the later stages of deposition of the 6″ shale band.

SUGGESTIONS FOR FURTHER STUDY

1. The sampling by bedding planes described above has suggested impressions of the multi-depositional nature of the sediments deposited in the environment of the Bendigo Goldfield.

2. The base of the bed was deposited by a uni-directional current from the SSE., of different speed strengths as evidenced by acutely separated directional modes, and significantly directed rosettes.

3. With further depositional phases, SSE. and SSW. sources were suggested by the didymograptid and phyllocarid populations, when their directional properties were studied separately.

4. Consideration of the random orientation of the pendent tetragraptid popula-

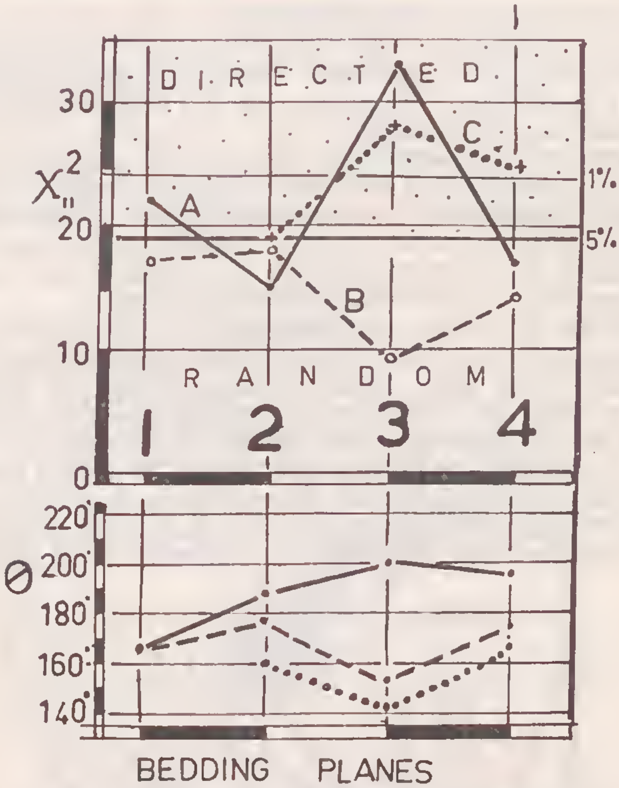

FIG. 3—Line graphs showing the stratigraphical variation of the significance and direction of orientation of the three fossil forms. A—Firm line (horizontal didymograptids); B—Broken line (pendent tetragraptids); C—Dotted line (phyllocarids).

tion throughout suggests that these may have been pelagic and some of these were winnowed and realigned when the SSE. or SSW. currents brought in the didymograptid and phyllocarid forms.

5. Closing phases of deposition suggested weakest currents with persistence of the SSW. bias, as suggested by more random modes, and symmetry considerations of the rosettes as a whole.

3. SAMPLING FROM THE WHOLE OUTCROP BY STUDYING THE ORIENTATION OF INDIVIDUAL FORMS

(a) *Tetragraptus fruticosus*: (3 Br. form). Pendent tetragraptids are suitable rhabdosomes for demonstrating the effect of distortion. If later compressive movement of the sediments is a factor in orientation, the stipe spread would be expected to be least perpendicular to the stress axis, and greatest in the direction of maximum compression. A study of stipe divergence was made in relation to length and orientation to gain some measure of the effect of stress deformation in particular directions.

Stipe divergence was measured by the ratio l/w, where l is the length of the rhabdosome from the first bifurcation to the distal end, and w is the distance across the distal extremities of the stipes perpendicular to the line of l, as indicated in Fig. 4. It should be realized that stipe divergence could be a function of the stage of growth of the species, since older forms become deflexed, the ratio l/w decreasing suddenly at a given length. As specimens in this band were less than one inch, this герontic feature was not present.

Fig. 4 demonstrates the change in the ratio l/w with increase in the length of a typical *Tetragraptus fruticosus* (3 Br.), in forms whose lengths do not exceed one inch. In all cases, as the rhabdosome grows, it elongates to a critical limit. Beyond this limit *T. fruticosus* stipes tend to curve outwards, so the ratio l/w decreases sharply in gerontism. If a current hypothesis is entertained, one would expect the more elongate particles to be the better indicators of current.

Fig. 5 shows the distribution of orientations of *T. fruticosus* (3 Br.) in relation to stipe divergence ratio (l/w). Table 2 summarizes the main features shown by the compound rosette. Since the more elongate forms are transversely distributed, as well as along the *a*-direction, the current hypothesis is favoured rather than orientation due to secondary stress factors. In some instances thecae may be distorted, but not complete rhabdosomes as figured by Hills (1965, p. 123, Fig. V-19). The smaller widespread forms are variable, and show the best symmetry in a NE.-SW. direction. This direction could be interpreted as tranverse to a SE.-SSE. current source, or to the response of realignment with a strong SSW. current

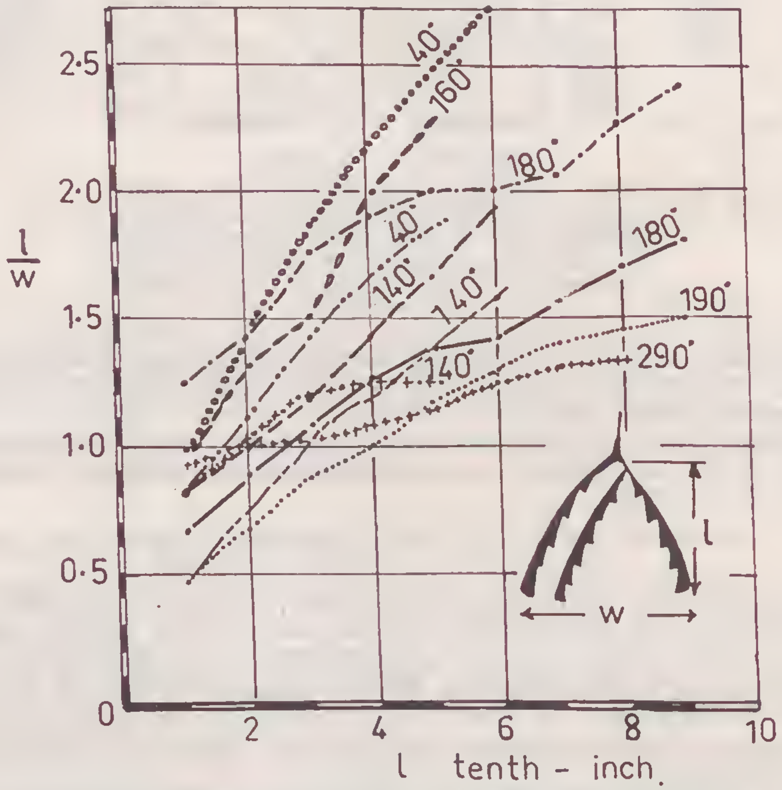

Fig. 4—Growth variation of stipe divergence of 10 of the longest *Tetragraptus fruticosus* (3 Br.) forms and their orientations.

which aligned the majority of horizontal extensiform didymograptids. In any case, the short, widely-diverging forms were fickle, and not accurate current indicators. The larger, elongate forms proved to be the more reliable indicators of current direction, which was from S.40°E.

(b) *Horizontal Didymograptids:* Size-orientation studies were carried out for the whole outcrop sample on horizontal extensiform didymograptids with fragmentary stipes and with complete rhabdosomes. Circular 30° class distributions allowed the determination of the significance of the attitude of thecae in relation

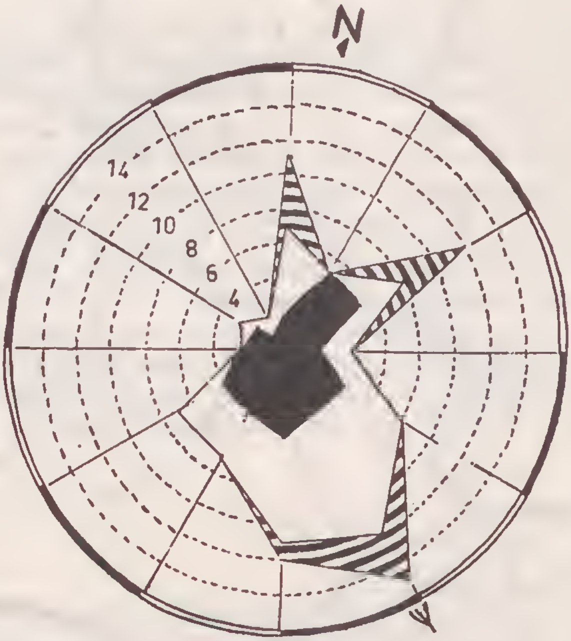

Fig. 5—Orientation of three classes of *T. fruticosus* (3 Br.) based on stipe divergence. Sample collected for the whole outcrop. (a) Striped: l/w = 2·0+; (b) Blank: l/w 1·5 to 2·0; (c) Black: l/w less than 1·5.

Table II

Analysis of Orientation of Tetragraptus Fruticosus (3 Br.) in terms of the Stipe Divergence Ratio (l/w) for all samples

Stipe Divergence Ratio (l/w)	Less than 1·5	1·5-2·0	Greater than 2·0
No. in Sample	42	36	12
Chi. Square Value (11 d.f. random)	6·0	22·0	30·0
Probability of random orientation	80%-90%	1 to 2·5%	0·5% to 1%
Inferred current source direction	140° and realignment from 210°	140°	140°

to stipe orientation. The direction of the sicula, (taken to be perpendicular to the stipe direction, but opposite in sense to the direction the thecae face), is plotted in relation to frequency in Fig. 6. Fig. 6A shows a transverse pattern for sicular orientation, with a small secondary mode pointing up-current, which gives the *a*-direction. This pattern is confirmed in Fig. 6B for the fragmentary stipes. There is no significant difference in the length of stipe studied. It was difficult to find sufficient numbers of short, horizontal rhabdosomes to compare with the tetragraptids less than 0·5″ (1 cm). The didymograptids have been aligned in a SSW. to S. direction with a small percentage of thecae pointing directly up or sub-transversely down current.

(c) *Didymograptus similis*: Fig. 7C, D shows the SSW. pattern as evidenced by normally disposed primary and secondary modes. *D. similis* incorporates all species with narrow proximal stipes flaring distally, usually less than 1·5″.

(d) *Didymograptus dilatans*: Fig. 7A, B shows the semi-circular distribution of the direction of that line equally inclined to the two stipes, and parallel to the join of the distal extremities of the rhabdosome, and the orientation of the sicula direction, respectively. The proximal angle of *D. dilatans* points obliquely downcurrent. Long stipes tend to sub-parallel or equally align themselves to the current direction, which is SW., and which largely agrees with that indicated by the alignment of the extensiform didymograptids.

(e) *Tetragraptus pendens*: It was not possible to obtain significant rosettes for the whole outcrop of *T. pendens*, even when the largest l/w values were considered. However, when samples for the lower pair of bedding planes were considered in relation to the upper pair, two significant distributions emerged as shown

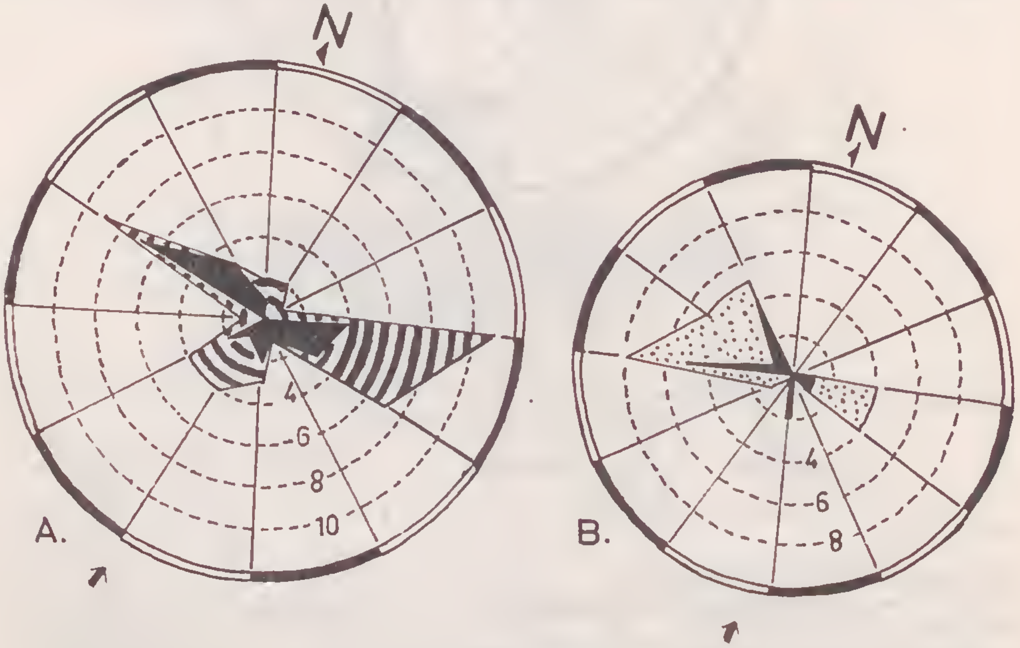

Fig. 6—Orientation directions of the siculae of horizontal extensiform didymograptids from the whole outcrop at Eaglehawk. A—Complete rhabdosomes: Black—less than 1″ long, Striped—more than 1″ long; B—Fragmentary rhabdosomes: Dotted—fragments longer than 1″, Black—not necessarily longer than 1″, but measured as definitely shorter.

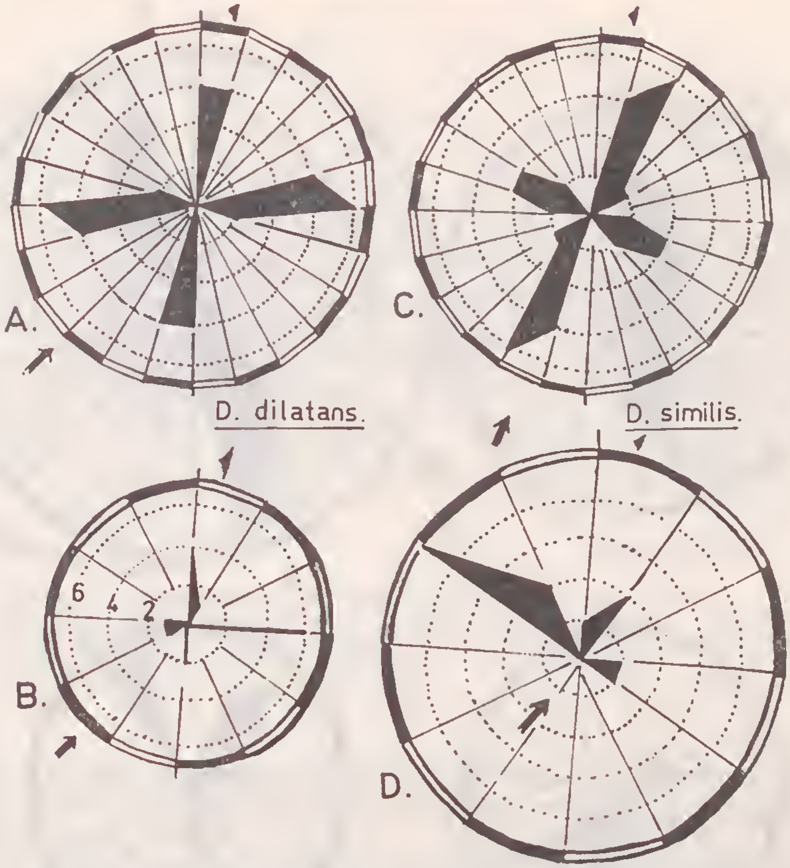

Fig. 7—Orientation patterns for *D. dilatans* (A, B) and *D. similis* (C, D). A, C—15° semi-circular distributions showing rhabdosome directions; B, D—30° circular distributions showing directions siculae were pointing.

in Fig. 8A, B. The lower bedding planes revealed a SW. current as with forms in Fig. 1A, B whilst the upper planes produced a symmetry which suggested a more southerly source. The interesting feature was that the siculae pointed dominantly downcurrent. At least the orientation patterns of *T. pendens* agree closely with those of *T. fruticosus* (3 Br.) and it would appear that both forms have been aligned in directions fitting a superposition of SSW. and SSE. directions. In general *T. pendens* is not a good indicator of current, but, when considered in conjunction with *T. fruticosus* (3 Br.) the sample of pendent tetragraptids becomes large enough to be significant.

(f) *Phyllocarid Carapaces*: Phyllocarids were studied for size and eccentricity of carapace in relation to the orientation direction. Fig. 9A portrays the orientation distribution in relation to the three categories of length. Carapaces less than 0·2″ were classified as short in length, 0·2″-0·4″ of medium length, and those above 0·4″ were regarded as long. The long ones were the most significantly orientated, the inferred direction being from the SSE.

The eccentricity *e* of the carapace is defined as the length-width ratio and Fig.

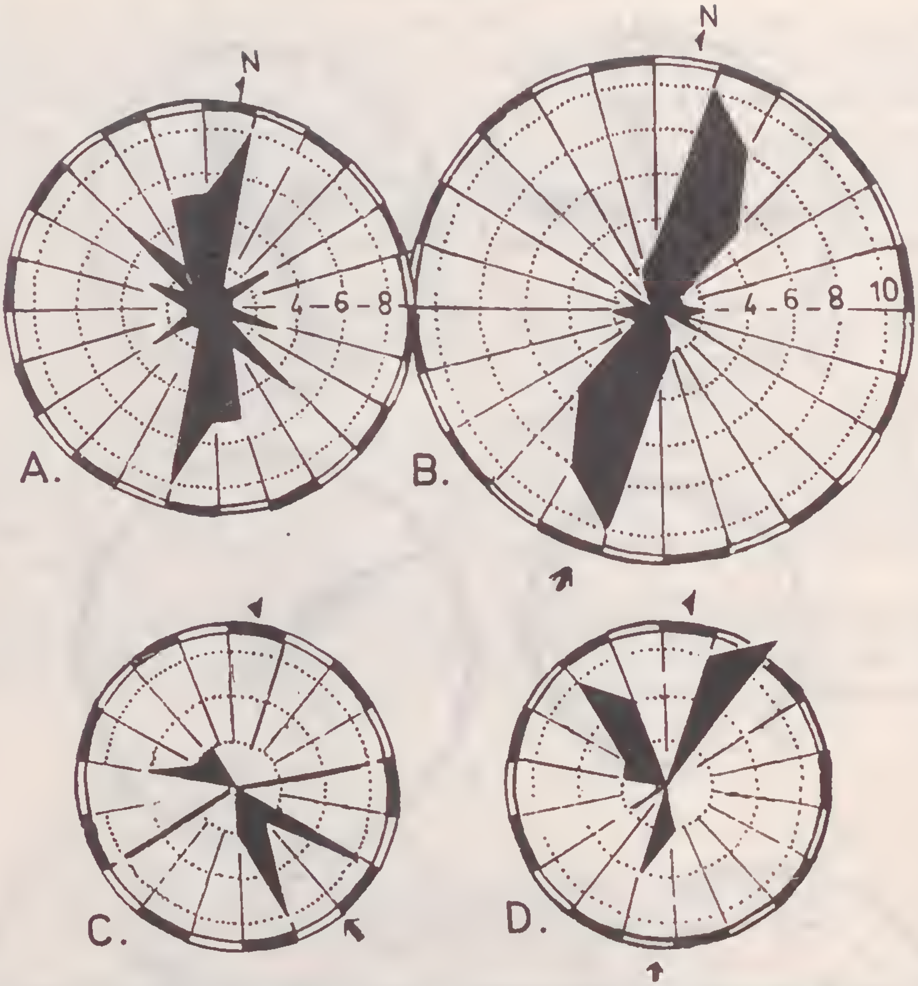

FIG. 8—Rosettes comparing orientations of horizontal didymograptids (A, B) with *T. pendens* (C, D) from lower and upper stratigraphical halves (AC, BD) respectively.

9B shows the relation between orientation and eccentricity. Again, the more elongate carapaces were most significantly orientated, again from the SSE. Carapaces below 2·6 *e* were not significantly orientated from random.

SUMMARY

At Eaglehawk, orientation studies dependent on form or species benefit greatly from size and shape sampling. The more reliable indicators are linearly shaped. In another study on the orientation of diplograptids from the Upper Ordovician localities of Toolern Vale and Diggers Rest, the author has shown that the longest forms prove to be the most reliable current indicators (Schleiger 1968). See Fig. 10.

Phyllocarids and pendent tetragraptids show a significant alignment consistent with a SSE. direction. Horizontal didymograptids on the other hand show a SSW. orientation pattern. The successive samplings in the rosettes suggest that the SSW.

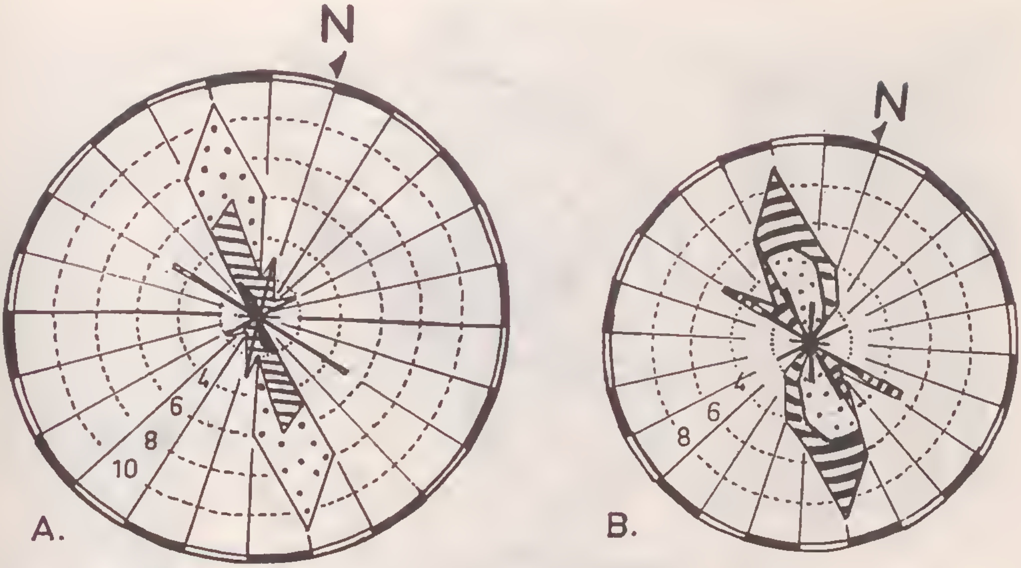

Fig. 9—Orientation of phyllocarids in relation to length and eccentricity of carapace. A—Length classes: Stippled—less than 0·4″ long, Striped—from 0·2″-0·4″, Black—less than 0·2″; B—Eccentricity classes: Striped—3·2+, Stippled—2·7 to 3·1, Black—less than 2·6.

current was operative in building up the later thicknesses of the bed, with the phyllocarids and tetragraptids showing some evidence of realignment in the uppermost bedding planes.

Otherwise a morphological hypothesis could suggest that the phyllocarids and pendent tetragraptids rotated or screwed as they settled through the current, since they were broader forms offering more resistance. Such rotatory motion could have produced modes at 40° to those of the linear extensiform didymograptids brought in from the SSW.

Whatever the reason, a vector mean of 168° can be calculated from the various rosettes (Tables III, V).

4. Methods of Sampling Graptolite Orientation

From the foregoing study the question of the best method of sampling of orientation patterns now suggests itself.

(a) Is a sample from one bedding plane using several forms representative of the whole outcrop?

(b) Is a study of one form over two or more bedding planes a better representation?

(c) Is a study of several forms collated from all bedding planes sampled, as good as either of the former two?

To test these three hypotheses, an analysis of variance was undertaken on the three estimates of the results, viz.,

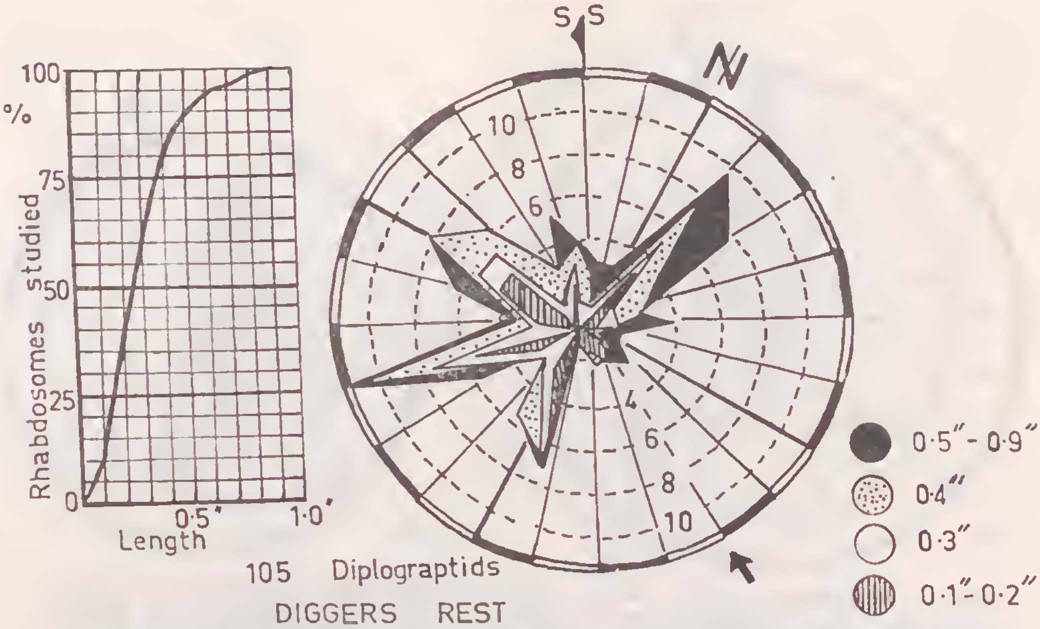

FIG. 10—Rosette showing the relation between length and orientation modes of diplograptids with inferred current. Individuals show a normal length distribution at left. Bolindian (Upper Ordovician). Locality on Jackson's Creek at 'Glencoe', Diggers Rest. ss: structural strike.

(a) those obtained from separate bedding plane samples; (3 forms and 4 planes);

(b) those obtained from rosettes of four forms from the lower and upper halves of the bed, by collating planes 1 and 2, contrasted with the combination of 3 and 4;

(c) those obtained by collating 12 different forms from the whole outcrop.

Table 3 presents the estimates for the three methods of sampling, and Table 4 the analysis of variance. It can be seen that of the various methods by bedding planes, by stratigraphical subdivision into two halves, and by collation for the whole outcrop of several forms, none is more accurate than another. However, species sampling does reveal significant differences at the 1 and 2·5 per cent levels. Thus, if the method of sampling involves only one species, it could lead to a result

TABLE III

Estimates for the Three Methods of Sampling of Graptolite Orientation Patterns, Eaglehawk

Sampling Method Species	A. Whole Outcrop	B. By Bedding Planes	C. By Lower & Upper Stratigraphic Halves
Horizontal Didymograptids	180, 185, 200, 185, 215, 190	140, 180, 205, 190	170, 195
Pendent Tetragraptids	210, 140, 140	150, 170, 165, 180	135, 180, 140, 145
Phyllocarid Carapaces	135, 140, 150	150, 155, 165	155, 160

TABLE IV

Analysis of Variation for the Three Methods of Sampling in Relation to Species of Table III

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Total for cells	8542·0	8		
Sampling methods	753·4	2	376·7	1·97
Species	7025·5	2	3512·8	18·41*
Species X sampling methods	763·1	4	190·8	
Within cells	8695·0	22	395·2	
Species in relation to within cells				8·89**

* Significant at the 1% level

** Significant at the 0·5% level.

TABLE V

Analysis of Sampling by Bedding Planes in Relation to like Hydrodynamic Forms of Orientation Patterns

Hydrodynamic Form	Bedding Plane Sampled				Total	n	Mean
	Base	Lower Middle	Upper Middle	Top			
Horizontal didymograptids	140	180	205	190	715	4	178·3
Pendent tetragraptids	150	170	180	165	665	4	166·3
Phyllocarid carapaces	NA	155	150	165	470	3	156·7
Total	290	505	535	520	1850	11	168·2
n	2	3	3	3		11	
Mean	145·0	168·3	178·3	173·3			168·2

TABLE VI

Analysis of Variation for Table V

Variation	Sum of Squares	D.F.	Mean Square	F. Ratio
Total	3763·6	10	376·36	
Bedding Pls.	1463·6	3	1254·4	4·35 (Sig. 5-10%)
Species	859·4	2	429·7	1·49
Error	1440·6	5	288·1	

which may not be truly representative of the inferred current direction at the locality.

Table 4 presents the method of sampling by bedding planes, in relation to only the three most abundant species. The analysis of variance indicates that forms on one particular bedding plane do not yield significantly different results from one another, but that bedding plane samples alone are almost significantly different from each other (at the 5 to 10% level). This calls for caution in taking individual bedding plane samples as representative. It would suggest that it would be safer to include approximately equal samples from several bedding planes for the most representative result.

SUMMARY

Where many graptolite forms are present, current direction from orientation sampling is best inferred by collating the more abundant, most elongate forms over two or more bedding planes. The more forms used, the more accurate will be the inferred direction. Preliminary sampling, however, will indicate whether it is worth while dealing with more than two forms, especially if bedding plane sampling is kept progressive, and the numbers of individuals kept in lots of 12 or 18 for ease of computation.

Inferences

1. Significant orientation of the commonly occurring fossil forms demonstrates the influence of primary current action rather than the effects of directional stress. Justification for this is realized in the study of the stipe divergence ratio of *Tetragraptus fruticosus* (3 Br.) where the longer, narrower forms were aligned in more than one direction, as were the short ones.

2. Sampling by four bedding planes of a six-inch shale bed on the orientation of horizontal didymograptids, pendent tetragraptids, and phyllocarid carapaces, reveals that the strongest aligning currents operated at the base of the bed; first unidirectionally from the SE., changing to S., then from the SSW., persisting to the deposition of the top of the bed.

3. The shift to SSW. was accompanied by strong orientation of horizontal didymograptids, realigning the shorter pendent tetragraptids and some oval phyllocarids, which already showed SSE. to SE. modes.

4. The longer, or more elongate particles were the most reliable indicators of current direction.

5. Methods of sampling by forms from the whole outcrop, or by stratigraphic units, are considered. Stratigraphic collation methods at Eaglehawk were not significantly different from each other. However, it is unsound practice to rely on one form from one bedding plane as being representative of the inferred direction at the outcrop. Rather two or more species from at least two or more bedding planes should prove more representative.

6. Whether the turbidity currents responsible for the abundance of graptolites over the shale bedding planes (Hills and Thomas 1954) were also responsible for the orientation of these fossils is not proven. It is reasonable to argue that the aligning current was associated with the same series of slumping movements which produced the turbidites which proved toxic to the graptolites. The initial slumping probably involved the emplacement of the heavy arenite beneath the graptolitic shale at Eaglehawk. The graptolitic shale represented the cloudy tail of clay particles left in the turbulent wake of the slump. If the turbulence circulated into the upper levels of the sea, with a toxic effect on the graptolites, it would be expected

that after these gravitated to the bottom, currents raking the floor, either the tail of the same turbidite or later bottom currents, would realign the rhabdosomes and phyllocarids.

Acknowledgements

The author is grateful to Messrs Gil. Medwell, Henry Moors, and Neil McLaurin for assistance in the field. Dr and Mrs John Talent, and Henry Moors were particularly helpful in their comments during the composition of the manuscript. Dr F. C. Beavis, Dept. of Geology, University of Melbourne critically read the manuscript, and gave helpful advice and encouragement during the project. Mr John Inglis of Coburg Teachers College gave valuable assistance with the photography. Costs were partly defrayed by a grant from the Science and Industry Endowment Fund, administered by C.S.I.R.O., East Melbourne, and part of the cost of publication has been met by the University of Melbourne.

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Explanation of Plates

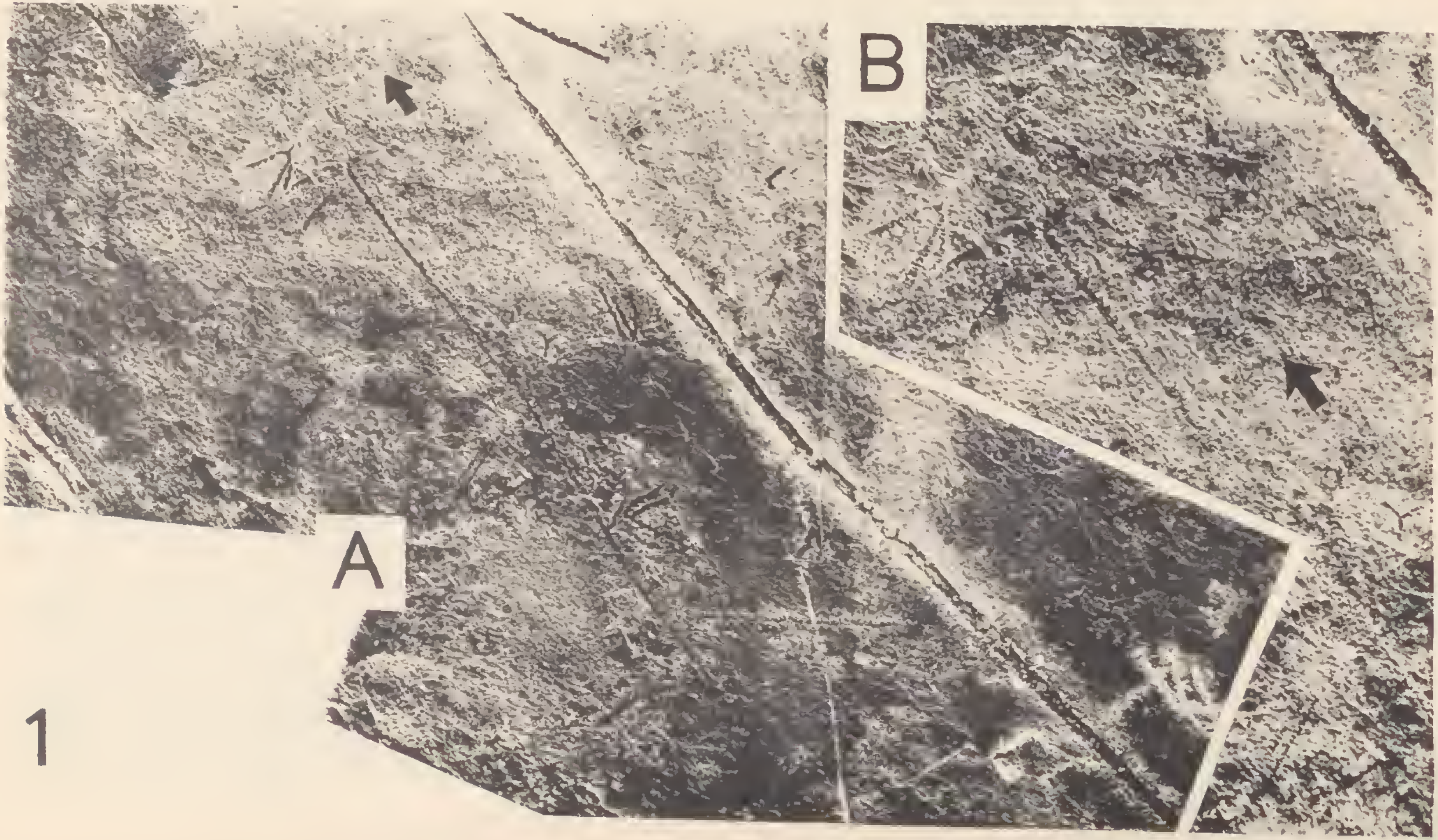
PLATE 1

A: Portion of the basal bedding plane showing extensiform didymograptids aligned along current, whilst the shorter rhabdosomes lie transverse to the current, which is from the SE. as indicated by the arrow.

B: Enlarged section of the left illustration to show a typical relationship between long didymograptids and pendent tetragraptids. Current indicated by arrow.

PLATE 2

Relation between aligned tetragraptids and transverse bedding parting lineation. The larger *T. fruticosus* (3 Br.) points proximally up-current (see arrow). The shorter form parallels the transverse bedding parting. Forms from Bedding Plane 1. (See Fig. 1B.)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A COMPARISON OF THE CAINOZOIC VOLCANIC PROVINCES OF VICTORIA AND TASMANIA

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Abstract

A comparison of the known Cainozoic volcanic histories of the Victorian and Tasmanian provinces indicates that there were distinct differences in the pattern of volcanicity in the two areas, although the petrology of the basaltic suites is similar.

Introduction

Volcanism was widespread in eastern Australia during the Cainozoic, and regional comparisons are of interest. This paper compares the Cainozoic volcanism in the Victorian and Tasmanian provinces, as far as known at present, and represents the basis of a paper given by the author at the 40th ANZAAS Congress in Christchurch, New Zealand, in January 1968.

Comparisons between the Cainozoic volcanic rocks of Tasmania and Victoria were made by Edwards (1950), following scattered sampling of the Tasmanian rocks, and he concluded that the relationships of petrology and eruptive age known in Victoria probably did not hold in Tasmania. Since Edwards's study, however, some of his data on ages of sub-basaltic sediments have proved invalid (see Sutherland and Corbett 1967). As considerably more information on Tasmanian Cainozoic volcanic successions is now available, a further review is justified.

Victorian Volcanism

Cainozoic volcanicity in Victoria is considered to be grouped about two maxima, one in the Eocene and the other in the Pliocene-Pleistocene (Singleton 1965). The Older Volcanic Series outcrops largely in Eastern Victoria, the parent magma belonging to the alkali olivine-basalt suite with an average SiO_2 content of about 46% (Edwards 1938). Lavas range from undersaturated olivine-basalts, some with basanitic affinities, to near-saturated olivine-basalts. Subordinate alkali differentiates include olivine-nephelinites, limburgites, and more rarely tinguaites, phonolites, and mugearites.

The Newer Volcanic Series outcrops almost entirely from Central to Western Victoria. Isotopic dating of the lavas (McDougall, Allsopp & Chamalaun 1966) gave ages ranging from 4·5 to 0·6 million years and radio-carbon dating (Gill 1964) indicates that volcanism occurred as recently as 5,000 years ago. The parent magma was more saturated than that of the Older Volcanic Series, with an average SiO_2 content of about 50% (Edwards 1937). Lavas range from near-saturated to saturated olivine-basalts, and subordinate alkali differentiates include limburgitic, mugearitic, trachytic, and sodic trachytic rocks.

Tasmanian Volcanism

In Tasmania the Cainozoic volcanic rocks show a similar compositional range to the Victorian rocks, although some differences can be noted. Monticellite and melilite bearing rocks amongst the undersaturated alkaline rocks in Tasmania (Edwards 1950) are unknown in Victoria. On the other hand, acidic differentiates of phonolitic and trachytic character as in Victoria, are as yet unrecorded from Tasmania. Small dykes and flows of hornblende-andesites have been discovered recently by D. J. Jennings and the author at Cape Portland, NE. Tasmania, post-dating Jurassic dolerite, but their precise age is unknown. These may represent acidic differentiates associated with nearby outcrops of typical Cainozoic olivine-basalts, but more probably represent the source of volcanic fragments in Lower Cretaceous sediments in Southern Victoria (Singleton 1965). Further, definite dates are not yet established for the phonolites and tinguaites attributed to the Older Volcanics in Victoria, and the possibility of a pre-Cainozoic age for these must be borne in mind, particularly as rocks of similar composition at Port Cygnet, Southern Tasmania, are dated as mid-Cretaceous (Spry 1962).

Several sections through Tasmanian Cainozoic volcanic sequences, with some age control, are now known and enable detailed comparisons to be made with Victorian sequences. Brief descriptions of these sequences are given below, and their probable stratigraphic relationships are summarized diagrammatically in Fig. 1. Summaries of the petrological characters of the Tasmanian basaltic suite are available from Edwards (1950) and Spry (1962).

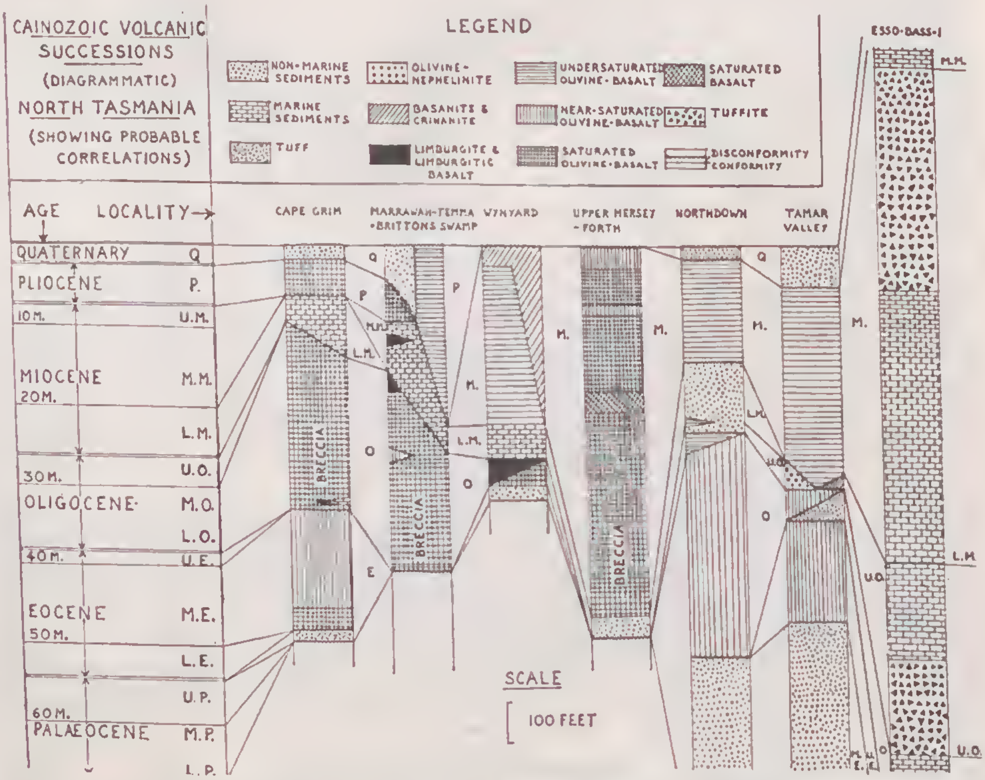

FIG. 1—Some Cainozoic volcanic stratigraphic successions (diagrammatic) in northern Tasmania, showing probable correlations.

(a) Cape Grim Area (Sutherland and Corbett 1967)

Lavas in this area disconformably underlie and overlie marine beds of Lower Miocene age, and stratigraphic considerations suggest that volcanic activity extended from Lower to Upper Tertiary time. The lavas are dominantly saturated olivine-basalts, with some near-saturated olivine-basalts.

(b) Marrawah-Temma-Brittons Swamp Area (Gill and Banks 1956; Sutherland and Corbett 1967)

Lavas at Marrawah are disconformably overlain by Mid-Miocene marine beds, and consist largely of saturated olivine-basalts, with some near-saturated olivine-basalt and limburgite. At Britton's Swamp 'palagonitised' and brecciated limburgite contains blocks of Miocene marine sediments (including pieces of Upper Longfordian age, P. G. Quilty, pers. comm.). A thick flow of undersaturated olivine-basalt disconformably overlies Lower Miocene marine beds at Mt Cameron West, and a flow of saturated olivine-basalt disconformably overlies Middle Miocene marine beds at Temma.

(c) Wynyard Area

Lavas underlie and overlie Lower Miocene marine beds in the area (Banks 1962; Quilty 1966; Gee 1966). Samples of the lavas from both above and below the marine beds were made available to the author for petrological examination by M. F. Harris following detailed mapping and sampling. Lava below the marine beds has been dated as Lower Tertiary on palaeomagnetic evidence (Green and Irving 1958) and these rocks include saturated olivine-basalt, limburgites and limburgitic basalts. Lavas overlying the marine beds are largely undersaturated olivine-basalts. The sediment/basalt contact appears generally comformable, and pillow-like lava occurs towards the base of the sequence just W. of Table Cape (R. D. Gee, pers. comm.). This may indicate eruption of lavas into the Miocene sea, but the evidence is uncertain. The highest part of the sequence appears to be basanite and is probably related to the intrusive neck of crinanite at Table Cape. The lavas are deeply weathered and lateritized in parts, suggesting an age not younger than Pliocene, and possibly pre-Pliocene.

(d) Upper Mersey-Forth Area (Spry 1958)

Pre-basaltic valleys in this area are filled with a succession of saturated olivine-basalts, near-saturated olivine-basalts and some saturated basalt. The lavas appear to have been erupted from centres near the Borradaile Plains and near Moina, where their age is established as probably Lower Miocene on palynological evidence (Paterson 1967).

(e) Northdown Area (Burns 1964)

Two separate basalt horizons are mapped in this area, and samples from both have been petrologically examined by the author. The older Thirlstane Basalt consists mainly of near-saturated olivine-basalt, and is disconformably overlain by non-marine beds dated as probably Upper Oligocene at the base, on palynological evidence. The sediments probably range up into the Lower Miocene and contain an interbedded flow of undersaturated olivine-basalt. The sediments are disconformably overlain by undersaturated olivine-basalt constituting the Moriarty Basalt, which is deeply weathered and lateritized suggesting an age not younger than Pliocene.

(f) TAMAR VALLEY AREA (Sutherland 1966)

The lavas in this area disconformably overlie Palaeocene-Middle Eocene non-marine beds. Detailed unpublished mapping and petrological studies by the author suggest that the lava succession in the Lower Tamar Valley consists of near-saturated olivine-basalts, with an initial Upper Eocene age, disconformably followed by flows of olivine-nephelinite and basanite, and finally a very thick flow of coarse undersaturated olivine-basalt. Considerable dissection and lateritization of the lava sequence suggests a probable pre-Pliocene upper age limit. This succession is of interest as it closely compares petrologically with that established for the Older Volcanic succession near Bacchus Marsh in Victoria (Jacobson and Scott 1937).

(g) BASS BASIN (Esso Exploration Australia, Inc. 1966)

Drilling in the Bass Basin (Esso-Bass-1) approximately 75 miles north of Table Cape proved a sequence of 6,857 ft of Upper Cretaceous to Upper Miocene non-marine, marine, and volcanic rocks. The volcanic rocks in the sequence include some tuffaceous sandstone at the base of the Oligocene, and tuffite cones in the Upper Oligocene and Lower Miocene beds. The author has examined thin sections of the tuffites, but the highly altered state of the rocks makes the basalt type difficult to determine.

Further data providing some age limitations on Tasmanian Cainozoic volcanic rocks are also known at the following places.

(1) STANLEY. The Nut, a probable neck of crinanite, has been dated as probably Lower Tertiary age on palaeomagnetic evidence (Edwards 1941; Gill and Banks 1956; Green and Irving 1958).

(2) GREAT LAKE. At Skittle Balls Plain, basalt has been dated as probably Upper Cainozoic on palaeomagnetic evidence (Green and Irving 1958). Petrological examination shows that the rock is saturated basalt.

(3) BRIGHTON. A flow of saturated olivine-basalt here is relatively little dissected, suggesting eruption in comparatively recent times, possibly in the late Tertiary (McDougall 1959).

(4) BRANXHOLM. Undersaturated olivine-basalt associated with olivine-nephelinite (Edwards 1950) here overlies non-marine beds, dated as probably Lower Miocene on palynological evidence (Harris 1965). Edwards (1939) considered the flows to be relatively young, either Pliocene or younger.

(5) GRANVILLE HARBOUR. A small outcrop of silicified marine limestone in the area appears to be disconformably succeeded by non-marine deposits overlain by basalt (Blissett 1962). The limestone is probably Middle Miocene in age by analogy with similar marine beds in north-west Tasmania (Quilty 1966), suggesting a post-Miocene age for the basalt. Petrological examination shows the rock is a saturated olivine-basalt.

(6) ST. HELENS. Boring in Thureau's Deep Lead here encountered basalt flows disconformably below sediments of probable Lower Oligocene age, on palynological dating (Jack 1964). The petrology of the basalt is unknown.

Conclusions and Discussion

Hence the following points can be made, in comparing Cainozoic volcanism in Victoria and Tasmania.

1. The volcanism commenced approximately contemporaneously in the two areas, during the Lower Tertiary, probably by Eocene time.

2. The volcanism ceased a little earlier in Tasmania than in Victoria, finishing probably in Pliocene or Pleistocene time. No eruptive cones or flow surface features are known in Tasmania with the degree of preservation of examples in the Newer Volcanics of Victoria (Ollier & Joyce 1964).

3. The volcanism appears to have been generally continuous in its activity in Tasmania, and not grouped about two maxima as in Victoria (Fig. 2). In contrast to Victoria, volcanism was prevalent in the Miocene in Tasmania. Here Tasmania resembles north-eastern New South Wales, where recent isotopic dating of lavas (McDougall and Wilkinson 1967) indicated widespread and prolonged activity in the Miocene. However Pliocene volcanism in north-eastern New South Wales appears to have been lacking or more subdued than in Tasmania.

4. Tasmania does not show the distinct relationship between basalt type, eruptive age and regional distribution as found in Victoria. In Tasmania there was approximately concomitant extrusion of both saturated and undersaturated lavas throughout much of the Cainozoic. Thus, extrusions of saturated olivine-basalts, typical of the Newer Volcanics of Victoria, commenced at least as early as Oligocene and possibly as early as Eocene in Tasmania. Similarly, undersaturated olivine-basalts similar to those of the Older Volcanics in Victoria were widely erupted in the Miocene, probably continuing into the Pliocene, in Tasmania. However, it has been suggested recently that some basalts in the Melbourne area in Victoria, petrologically resembling the Older Volcanic rocks, may be as young as Upper Pliocene (Thomas, *et al.* 1967). Thus, when detailed dating of rocks attributed to the Older Volcanics is done, it may well be found that the Cainozoic volcanic history of Victoria approaches the Tasmanian pattern more than the present picture suggests.

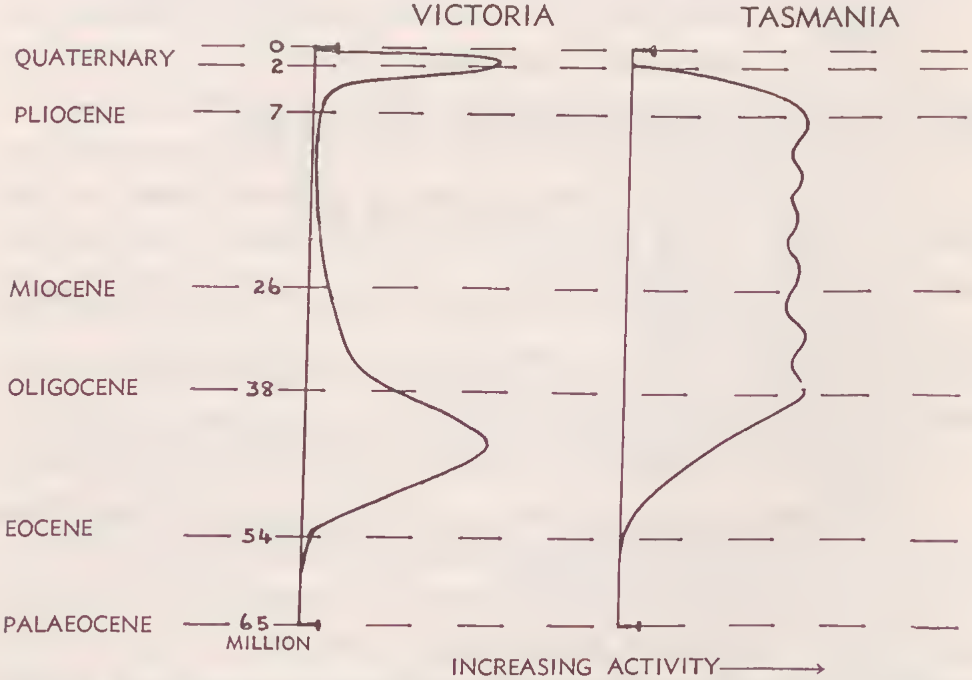

FIG. 2—Approximate comparative patterns of Cainozoic volcanic activity in Victoria and Tasmania.

In the final analysis, however, the comparisons indicate a distinct difference in the pattern of Cainozoic volcanism in Victoria and Tasmania.

Acknowledgements

The author gratefully acknowledges the assistance of Mr M. F. Harris, formerly of the Geology Department, University of Tasmania, who provided samples and information on rocks in the Wynyard area; Mr B. M. Hopkins, Hematite Petroleum Pty. Ltd., who gave permission for the author to see the Esso-Bass No. 1 well completion report, and include reference to the well in the paper; and Mr I. B. Jennings, Chief Geologist, Mines Department of Tasmania, who arranged for the author to examine cores from Esso-Bass-1 well.

The manuscript was kindly read for the author by Mr M. R. Banks, Geology Department, University of Tasmania, and Mr E. D. Gill, Assistant Director, National Museum of Victoria.

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14

OSTEOLOGY OF *Pedionomus torquatus* (AVES: PEDIONOMIDAE) AND ITS ALLIES

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Abstract

The skeleton of *Pedionomus* is described and compared with those of *Turnix* and *Ortyxelos. Turnix* and *Ortyxelos* are quite similar to one another in most features of their skeleton, but are quite different from *Pedionomus* in many characteristics of the skull, sternum, pectoral girdle, wing and synsacrum. Only the elements of the hind limb are similar in these genera. The osteological evidence supports the current taxonomic status of *Turnix* and *Ortyxelos* as separate genera in the family Turnicidae. In view of the distinction of *Pedionomus* it is suggested, as a practical taxonomic conclusion, that the general practice of placing *Pedionomus* in a separate family, the Pedionomidae, be maintained. Several aspects in the definitions of palate and nostril types are discussed with the conclusion that the members of the Turnices possess a schizognathous palate and a schizorhinal nostril.

Introduction

The endemic Australian Plain-Wanderer (*Pedionomus torquatus*) has been known to science for over 100 years, yets its morphology is still little studied and its exact affinity with other birds remains disputed. The only anatomical study of this bird, to our knowledge, is the short contribution by Gadow (1891) which forms the basis of all subsequent taxonomic conclusions (but see Appendix 2). Gadow concluded (1891 : 211) that *Pedionomus* should be placed in the Turnices, a suborder of the Gruiformes that includes the Turnicidae (Button quails). Opinion differs on the closeness of relationship between the Pedionomidae and the Turnicidae. Mayr and Amadon (1951) believe that these taxa are distinct only on the subfamilial level, whereas Stresemann (1927-34: 760) and Wetmore (1960: 11) believe that these birds are more distinct and should be placed in separate families. Most classifications follow the latter course. Yet none of these opinions have any solid foundation because of the lack of comparative analyses of anatomical and other pertinent taxonomic characters.

A major reason for the lack of anatomical studies of *Pedionomus* is the rarity of anatomical specimens of this bird; no skeletons exist, to our knowledge, in any American or European museum. Lowe (1923: 279) makes the same observation on the rarity of specimens of many problem genera in the introduction of his study on the turnicid genus *Ortyxelos*. Hence, we seized upon the opportunity of McEvey's stay in New York to undertake an investigation of the skeletons of *Pedionomus* in the collections of the National Museum of Victoria. Although we shall focus attention in this study on the osteology of *Pedionomus*, the details of the morphology of *Turnix* and of *Ortyxelos* cannot be overlooked. Excellent studies of the skull (and post-cranial skeleton, partly) of *Turnix* are available (Huxley 1867, 1868; Parker 1863, 1866, 1868, 1875), and the skull and several elements of the post-cranial skeleton of *Ortyxelos* were described (some parts very briefly) by Lowe (1923); yet a detailed analysis of the skeleton of these genera is not available as a basis for comparison with that of *Pedionomus*. The goal of this study is to present a comparative description of the skeletons of *Pedionomus, Turnix* and *Ortyxelos* as a foundation for further taxonomic work. The time available to us did not permit comparison of the osteology of these birds with other members of the Gruiformes and related orders.

The African genus *Ortyxelos* deserves a word of introduction. This bird was originally and correctly described by Vieillot as a member of the genus *Turnix* and shortly thereafter placed in a monotypic genus *Ortyxelos* by the same author. However, many subsequent workers believed it to be related to the shorebirds in the broadest sense and placed it in one or another family within the Charadriiformes in many works; *Ortyxelos* cannot be found under the Turnicidae in most studies published in the last century. Sharpe included it in the Glareolidae (his Cursoriidae) in his 'Catalogue of Birds in the British Museum' (Vol. 24). Lowe (1923), after a comparative study of the skeleton, reassigned *Ortyxelos* to the Turnicidae, a conclusion that has been followed by Peters in his 'Check-list' and by most other subsequent workers. We accepted Lowe's conclusion as a working hypothesis at the onset of our study and concurred with it ever more strongly as our work proceeded. The spelling of the generic name of this hemipode must also be clarified. The original and correct spelling is *Ortyxelos* used by Vieillot and followed by Peters (1934: 149) in his 'Check-list'. For reasons unknown to us, this name has been emended to *Ortyxelus* and is so used by Sharpe in his 'Catalogue' (Vol. 24), Lowe (1923), Stresemann (1927-34: 759-760, who uses both spellings), Wetmore (1960) and many other authors. We are not aware of any valid reasons for this emendation and would urge that the spelling of *Ortyxelos* be followed.

Acknowledgements

We would like to thank the officials of the Bird Room, British Museum (Natural History), and of the Department of Birds, U.S. National Museum, who kindly made available to us skeletal specimens under their care. Dr H. Morioka assisted the study in many ways and has kindly read the manuscript for which we are most grateful. We would like especially to thank Mrs Frances Jewel who devoted more than her usual skill and care in executing the drawings that accompany the text and greatly enhance the value of this study. Special mention and thanks must be given to Major Harold Hall, O.B.E., M.C., and to the Myer Foundation, the Ian Potter Foundation and the M. A. Ingram Trust, for generously enabling Allan McEvey to spend a month in New York to take part in this research. This study was supported by grant N.S.F. GB-3802 from the National Science Foundation to Walter Bock.

Materials and Methods

The following skeletons were available and used in this study: *Pedionomus torquatus*, three complete specimens (National Museum of Victoria: W6084; W6655; W6698; these specimens were thoroughly cleaned, bleached and disarticulated); *Ortyxelos meiffrenii*, two partly damaged specimens (British Museum, Natural History: S/1952.2.71; S/1956.22.1; these specimens were thoroughly cleaned and disarticulated; only the mandible, upper jaw and parts of the bony palate were lacking from these specimens which are the same ones studied earlier by Lowe); *Turnix sylvatica*, three complete specimens (U.S. Nat. Mus.: 344362; 344365; 429078); *T. tanki*, one complete specimen (Amer. Mus. Nat. Hist.: 1581); *T. suscitator*, one complete specimen (U.S. Nat. Mus.: 347288); *T. nigricollis*, two complete specimens (Amer. Mus. Nat. Hist.: 1944; 5381); *T. varia*, one complete specimen (Amer. Mus. Nat. Hist.: 1601); and *T. pyrrhothorax*, skull and mandible (National Museum of Victoria: 665). No special care was taken to obtain specimens of all species of *Turnix* although we did try to include representatives of larger species such as *varia* and heavy-billed forms such as *pyrrhothorax*.

Observations and drawings were made with the assistance of a stereo dissecting microscope. A Wild M5 microscope equipped with a drawing tube (camera lucida) was used for the drawing of all figures; care was taken to use the centre of the field to reduce the amount of spherical aberration which occurs at the edge of the field.

Terminology for the parts of the skull follows general standard usage and in particular follows the usage in earlier papers by Bock. (The reader is referred to Appendix 1 for a clarification of earlier usage of basipterygoid and basitemporal articulation.) Terminology for the parts of the post-cranial skeleton follows Howard (1929) with the addition of a few terms for structures not covered by Howard's terminology.

Description

In all descriptions of the skeleton, the bony elements of *Pedionomus* will be described first, followed by a description of *Turnix* and a briefer description of *Ortyxelos* only when it differs sufficiently from *Turnix*. A comparison of the bony element of the three genera follows the description. Because *Ortyxelos* and *Turnix* are similar in many parts of the skeleton, most of the comparison will be between *Pedionomus* and *Turnix*. The accompanying figures of each genus were drawn from favourable elements chosen from the available specimens to provide the most representative and accurate portrayal of the osteology. Some elements of *Ortyxelos*, notably the skull, were too badly damaged to figure. Reference should be made to Lowe (1923) who illustrated several bony elements of this genus.

THE SKULL AND LOWER JAW

PEDIONOMUS

Braincase: The entire skull of *Pedionomus* (Fig. 1) is lightly built with the upper jaw depressed about 30° below the longitudinal axis of the basisphenoid rostrum. The braincase is high and wide but relatively short; the height is about three-quarters the braincase width, whereas the length is only half the width. In dorsal view, the posterior margin of the braincase is relatively flat with a small pointed projection just above the occipital plate. The supraorbital rims are narrow with a distinct median furrow between them; the furrow extends to the base of the upper jaw. No supraorbital grooves for nasal glands (absent in this bird?) exist. The width of the skull at the dorsal end of the lateral nasal bars (anterior limits of frontal) is equal to or just less than the width between the jugal bars. In lateral view, the anterior end of the supraorbital rim slopes down sharply to the base of the upper jaw. The orbit is quite large, about one-third the length of the skull, and the orbital septum is only partly ossified. A small postorbital process is present just inside the lateral edge of the postorbital wall. Only the faintest suggestion of a temporal fossa exists on the lateral edge of the postorbital wall. An indistinct hollow is present on the postorbital wall just medial to the postorbital process and dorsal to the quadrate. A minute zygomatic process lies just above the squamosal articulation of the quadrate and again inside the lateral edge of the postorbital wall. A slightly larger suprameatic process lies ventral to the zygomatic process. A small, but distinct, suprameatic fossa lies at the bases of the zygomatic and suprameatic processes.

The occipital plate is elevated about 30° above the axis of the basisphenoid rostrum. The foramen magnum is large with the exact shape of its dorsoposterior margin depending upon the degree of ossification (presumably becoming rounder in older individuals). Moderate-sized auditory bullae flank the foramen magnum and the basitemporal plate; these bullae are solidly constructed, not thin walled shells as found in many birds. The basitemporal plate is flat with small lateral processes which are presumably capped, in life, with fibrous pads. The eustachian tube is expanded with a characteristically large opening above the lateral edge of the basitemporal plate and medial to the otic process of the quadrate. The basisphenoid rostrum is moderately inflated with small basipteryoid processes just anterior to the tip of the basitemporal plate.

Ectethmoid: The ectethmoid plate is rather small and rectangular in shape with a sharp ventrolateral projection; the ectethmoid does not project laterally beyond the outer limits of the lateral nasal bars. No ossifications attach to the anterior surface of the ectethmoid and the lacrymal is absent; the antorbital space, therefore, does not contain any ossifications. The ectethmoid foramen is single and large, extending almost to the lateral edge of the bone.

Upper Jaw: The upper jaw is just less than half the length of the skull and is straight with a slight dip at its tip. The nostril is large, extending about three-quarters the length of the upper jaw and is completely unossified. The posterior end of the nostril extends back just beyond the base of the upper jaw (schizorhinal), and is relatively wide and rounded. The ossified orbital septum extends forward slightly beyond the base of the upper jaw; hence, the skull is rhynchokinetic of the charadriiform type (Bock 1964a: 14-15). Close examination reveals that a flange of bone extends from the dorsal edge of the orbital septum to the lateral margin of the medial dorsal bar of the upper jaw. This flange lies just under the medial dorsal bar and a fraction can just be seen in the posterior end of the nostril (Fig. 1A).

Quadrate: The quadrate is low with its longitudinal axis inclined about 60° anterior to the vertical when the palate is in the resting retracted position. It has the usual double squamosal articulation with the medial facet on the squamosal slightly posterior and ventral to the lateral facet (Fig. 2). The dorsal head of the squamosal articulation lies between and is partly hidden by the zygomatic and suprameatic processes. These processes embrace the lateral half of the quadrate head between them. The orbital process of the quadrate is moderately short and broad, whereas the base is quite broad and short (in anteroposterior length). The lateral articular condyle and jugal articulation of the quadrate flare laterally as far as the lateral margins of the brain case. The articular condyles are flat with only the medial condyle projecting downwards as a distinct rounded knob. The posterior condyle lies between and behind the lateral and medial condyles as a distinct ridge extending from the lateral condyle.

BONY PALATE: The pterygoid is a flat, broad and slightly twisted bone. It appears to be slightly bent at the basipterygoid articulation but this may be more apparent than real, resulting from the low process at the basipterygoid articulation. Both the pterygoid and palatine clasp the basisphenoid rostrum at their common articulation. However, the two lateral halves of the palate do not meet at any point along the midline. The palatine shelf that is concave ventrally, has a distinct posterolateral corner, short mediopalatine and interpalatine processes and a straight prepalatine bar (or process).

The exact structure of the vomer cannot be given with complete certainty. In all specimens, the vomer appeared to be limited to a pair of anterior processes extending from the anterodorsal corner of each palatine and lying along the basisphenoid rostrum (Fig. 1D); these correspond to the bars connecting the anterior plate of the vomer to the palatines in *Turnix* and other birds. No anterior medial ossification was seen attached to these processes in any specimen of *Pedionomus* available to us, and hence our initial conclusion was that the vomer is greatly reduced or absent in this genus. However, the anterior ossification of the vomer may be present but weakly attached to the posterior connecting bars and may fall off during preparation of the specimens. The skeletal specimens of *Pedionomus* were thoroughly cleaned and became extensively disarticulated during preparation. After careful search, a small bone was found with one specimen (N.M.V. W6084) that is most likely the anterior medial part of the vomer (Figs. 1E, 3). This bone is the right size and shape, and possesses long articular facets on its dorsal surface that correspond to the processes extending from the palatines. This bone does not correspond to any other element of the skeleton and we have identified it tentatively as the anterior ossification of the vomer. As such, the vomer is elongated, relatively narrow, has a slight ventral keel and has a pointed anterior tip. The tip of the vomer would extend anterior to the maxillo-palatines. The vomer is somewhat broader than in the typical schizognathous condition; however, it agrees closely with the basic characteristics of the schizognathous palate and not with the aegithognathous palate. Hence, we designate *Pedionomus* as a schizognathous bird.

MAXILLO-PALATINES: The jugals are thin and converge gradually and evenly from the quadrates to the base of the upper jaw. The jugal bar, prepalatine bar, lateral nasal bar and base of the maxillo-palatine pedicle meet at a common point at the ventral base of the upper jaw. The pedicle of the maxillo-palatine is fused to the dorsal surface of the prepalatine bar. The maxillo-palatine has a broad pedicle and an expanded flat tip that would cover much of the vomer when viewed from the ventral side.

MANDIBLE: The mandible of *Pedionomus* (Figs. 1D, 8B and 9B) is slightly decurved without any prominent muscular attachments or articular surfaces except for a deep groove for the medial condyle at the base of the internal process. It has a characteristic double mandibular foramen. An external process just anterior to the articulation indicates that a postorbital ligament may be present. The retroarticular and internal processes of the mandible are short and broad; these processes are connected by a low posterior wall of the articular cavity. The internal process (Fig. 8B) articulates with the ventral tip of the lateral process of the basitemporal plate to form the secondary articulation (and brace) of the mandible (Bock 1960).

TURNIX

In addition to figuring the skull of *T. nigricollis* (Figs. 4, 8A and 9A) a typical member of the genus, we figure the skulls of *T. varia* (Fig. 6), which is one of the largest members of the genus, and of *T. pyrrhothorax* (Figs. 5 and 9C), which possesses the heaviest bill in the genus and in the entire Turnices complex. The following description will be based upon the skull of *T. nigricollis* with reference to other members of the genus only on points of sufficient difference.

BRAINCASE: The entire skull of *Turnix* (Figs. 4, 5 and 6) is lightly built, although somewhat more solid than in *Pedionomus*, with the upper jaw depressed about 20° below the longitudinal axis of the basisphenoid rostrum. The braincase is lower, narrower and relatively long; the height is slightly less than the braincase width, whereas the length is three-quarters the width. In dorsal view, the posterior margin projects backwards; this projection and elongation of the braincase is most apparent in lateral view. The supraorbital rims are wide and flat without any indications of grooves for nasal glands. The width of the skull at the confluence of the frontals and ectethmoid plates is slightly greater than the width between the outer surfaces of the jugal bars; the dorsal end of the lateral nasal bars lies just medial to the edge of the skull. In lateral view, the anterior end of the supraorbital rim slopes down gradually to the base of the upper jaw. The orbit is a little lower and smaller than in *Pedionomus*, just under one-third the length of the skull, and the orbital septum is only partly ossified. A minute postorbital process is present on the lateral edge of the postorbital wall. The zygomatic process is well-developed and covers completely the dorsal head of the quadrate-squamosal articulation; this process is forked in *T. pyrrhothorax* and *varia*. The suprameatic process is fused with the zygomatic process, although the two processes are distinct in some (young?) specimens. No temporal fossa exists, although a shallow hollow is present on the lateral wall of the braincase just posterior to the edge of the orbit. A small suprameatic fossa is present on the ventrolateral surface of the zygomatic process. The lateral edge of the postorbital wall and the zygomatic process flare out to form a well-marked hollow on the lateral portion of the postorbital wall just dorsal to the quadrate. This hollow apparently serves as the origin of the M. adductor mandibulis externus rostralis. A small but distinct process lies at the anterodorsal edge of the auditory bulla just above the external auditory meatus in some species as *T. tanki, varia* and *pyrrhothorax*; this may be called the posterior meatic process.

The occipital plate is elevated about 30° above the axis of the basisphenoid rostrum. The base of the braincase is similar to that in *Pedionomus* except that the auditory bullae are rather flatter and the lateral processes of the basitemporal plate are slightly better developed.

ECTETHMOID: The ectethmoid plate is broader and merges fully and smoothly with the frontal; it forms a definite anterior wall of the orbit. It is thicker than in *Pedionomus* with the well-ossified alinasal filling the dorsal half of the antorbital cavity. The alinasal is fused rigidly with the ectethmoid and with the base of the upper jaw, extending as far forward as the ossified orbital septum with which it is continuous. In dorsal view, the ossified alinasal fills the posterior end of the nostril. The lacrymal appears to be absent. A small ectethmoid foramen (divided in *T. sylvatica*, U.S.N.M. 429078) is present at the mediodorsal corner of the ectethmoid plate and a minute foramen is present at or near the dorsolateral corner of the ectethmoid in a few forms (*T. varia*, A.M.N.H. 1601; and *T. suscitator*, U.S.N.M. 347288). The lateral foramen may be present in more specimens but could not be detected because of damage to the bone or because of dried tissue obscuring it. In some specimens a small groove is present at the junction of the ectethmoid plate and the supraorbital rims which probably corresponds to the lateral foramen. A small foramen is present on the anterodorsal face of the ossified alinasal just anterior to the posterior end of the nostril; this foramen is the anterior opening of the canal starting at the medial ectethmoid foramen.

UPPER JAW: Except for the ossified alinasal, the upper jaw and nostril (schizorhinal) of *T. nigricollis* are similar to those of *Pedionomus*. The jaw of *T. pyrrhothorax* is shorter, stouter and less depressed than in *nigricollis* with heavier dorsal and ventral bars and a more massive anterior tip. The anterior extension of the ossified orbital septum, which has a lateral flange extending under the medial dorsal bar as in *Pedionomus*, is hidden by the alinasal in lateral view. The skull of *Turnix* is rhynchokinetic of the charadriiform type.

QUADRATE: The quadrate of *Turnix* is similar to that of *Pedionomus* with a few exceptions. The dorsal head of the squamosal articulation is completely hidden by the combined zygomatic and supermeatic processes. Both the lateral and the medial articular condyles are sharply defined knobs with a deep groove between them. The posterior condyle is reduced to a small, elevated knob immediately behind the medial condyle.

BONY PALATE: The pterygoid is slightly more massive and has a more distinct bend at the basipterygoid articulation than in *Pedionomus*. The mediopalatine processes meet along the midline. The palatine shelf is narrow with a gradually sloping posterolateral corner, (much squarer in some *T. pyrrhothorax* than as shown in Fig. 5C); the shelf is concave ventrally. A distinct interpalatine process and a long straight prepalatine process (= bar) are present.

The vomer comprises a pair of long thin processes extending from the palatine and a short pointed anteromedial plate. It is basically similar to the vomer in *Pedionomus* except that the anterior plate is shorter. The anterior plate of the vomer varies considerably among the species of *Turnix* (Fig. 7) from a plate of moderate width and pointed anterior tip to one of broad width and truncated tip with a pair of lateral horns. The anterior plate in *pyrrhothorax* is very broad and has a squared tip; the latter may be (but probably is not) the result of damage during preparation. Hence, the palate of *Turnix* varies from a fairly typical schizognathous one to an apparently aegithognathous one according to the criteria established in recent discussions (see below, p. 204–5); however, the palate of all species of *Turnix* is clearly schizognathous.

MAXILLO-PALATINES: The jugal bar, lateral nasal bar and base of the maxillopalatine pedicle meet at a common point, but the prepalatine bars arise from a more anterior point on the upper jaw. The pedicle of the maxillo-palatine is very thin and it usually meets and fuses to the prepalatine bar where it passes dorsally to that bone; the pedicle of the maxillo-palatine does not touch the prepalatine bar in *T. varia*. The free tip of the maxillo-palatine is a small plate that is scarcely larger than the width of the pedicle.

MANDIBLE: The mandible of most species of *Turnix* is slightly thinner and more decurved than that of *Pedionomus* (Figs. 4C, 5B, 8A, 9A and 9C). A small but distinct knob on the dorsal edge of the ramus may serve for the insertion of the M. adductor mandibulis externus rostralis; this knob correlates with the hollow on the lateral part of the postorbital wall. The articular surface is broad and flat except for a distinct groove for the medial condyle. A broad lateral shelf exists corresponding to the wide lateral condyle. The retroarticular process is long and narrow, and the internal process is long, narrow and curves forward at its tip. The posterior wall of the articular cavity is absent; hence, a deep groove separates the retroarticular and internal processes. The tip of the internal process articulates with the ventral tip of the lateral process of the basitemporal plate (Fig. 8A).

The mandible of *T. pyrrhothorax* (Figs. 5B and 9C) is straight and deep with a moderately high coronoid process. A distinct bony knob is present at the posterodorsal corner of the coronoid process, probably for insertion of the M. adductor mandibulis externus rostralis. The articular facet for the lateral condyle lies on the lateral flange and is considerably higher than the articular facet for the medial condyle. The retroarticular process is short, but the internal process is long, narrow and curves forward at its tip. The posterior wall of the articular cavity is absent. The massive mandible of this species corresponds to the heavy upper jaw.

ORTYXELOS

Although the skulls of the available specimens of *Ortyxelos* were badly damaged, most parts except the upper jaw could be examined and compared with Lowe's (1923) description and text. Basically the skull is very similar to that of *Turnix* as stated by Lowe. The major points of difference are as follow.

BRAINCASE: The postorbital process is completely lacking. The zygomatic process is smaller, but still covers the dorsal head of the quadrate-squamosal articulation. But the lateral edge of the postorbital wall forms a simple corner with the temporal wall of the braincase; the hollow seen in *Turnix* is absent.

ECTETHMOID: A small ectethmoid foramen is present at the mediodorsal corner of the ectethmoid and a second small foramen is present on the dorsal margin of the ectethmoid about halfway out to the lateral edge of the skull.

QUADRATE: The posterior articular condyle has disappeared completely, leaving the lateral and medial condyle as distinct knobs separated by a deep groove and lying in a straight line resulting in a quite unusual configuration; the structure of these condyles is not shown in Lowe's figure (1923, Fig. 2A).

PALATE: The two palatines apparently do not meet along the midline as shown by Lowe. The palatine is considerably smaller than in *Turnix* with a smaller and less concave palatine shelf, although the overall shape of the palatine in *Ortyxelos* is similar to that in *Turnix*.

The processes connecting the palatines with the anterior plate of the vomer are missing as noted by Lowe, although this may be due to incomplete ossification because of age. The vomer is moderately broad with a pointed tip and similar to that seen in some species of *Turnix* and in *Pedionomus*. We would characterize the palate of *Ortyxelos* as schizognathous.

MANDIBLE: The lower jaw of both specimens was lost. Lowe did not describe it.

COMPARISON

The skulls of *Turnix* and *Ortyxelos* are very similar as Lowe (1923) has noted previously. The absence of the posterior articular condyle of the quadrate in *Ortyxelos* is the culmination of a trend seen in *Turnix*. The lack of the postorbital process and of the hollow in the lateral edge of the postorbital wall in *Ortyxelos* versus the minute postorbital process and the distinct postorbital hollow in *Turnix*, and the differences in size of the palatines in the two genera are minor compared to the overall similarity of these genera and to the suite of differences between these genera and *Pedionomus*.

Although the skulls of *Pedionomus* and of *Turnix* appear to be basically similar, the degree of this resemblance and its interpretation cannot be ascertained without further comparison with other birds. It is entirely possible that similarities between these genera indicate only that both forms are members of a broader group than an avian family. Hence, in this and all later comparisons, we shall emphasize only the differences between these genera, but with the warning that this method may introduce an artificial bias suggesting that these birds are more dissimilar and more distantly related than they actually are. No such conclusion is warranted on the factual basis of this study because of the lack of comparison with additional birds.

The braincase differs in its overall proportions, with *Pedionomus* having a higher, wider and shorter braincase with a larger orbit and narrow supraorbital rims. *Pedionomus* has a more distinct postorbital process, but lacks the large zygomatic process and has only a small hollow on the postorbital wall as opposed to the larger hollow in *Turnix*. The ectethmoid of the two genera is markedly different in size and shape, in the size of the ectethmoid foramen (large in *Pedionomus*) and in the presence of a large ossified alinasal fused to the anterior ectethmoid surface in *Turnix*. The articular condyles of the quadrate differ in that the posterior condyle is small and a distinct groove separates the lateral and medial condyles in *Turnix*. The size and shape of the palatines differ with this bone being smaller and having a sloping posterolateral corner in *Turnix*. The vomer of *Turnix* tends towards an aegithognathous condition in some species. The maxillo-palatines of *Turnix* are much narrower than those of *Pedionomus* with minutely expanded tips. The retroarticular and internal processes in *Turnix* are longer and narrow without a posterior wall connecting them. The lateral portion of the articular surfaces in *Turnix* flares out beyond the edge of the ramus.

Thus almost every portion of the skull of *Pedionomus* can be distinguished from those of *Turnix* with many of the differences being obvious and clear cut. *Ortyxelos* is close to *Turnix* and neither form can be regarded as a morphological intermediate between *Pedionomus* and the other genus.

STERNUM

PEDIONOMUS

The sternum of *Pedionomus* (Figs. 10 and 13A) is very broad in relation to its length; the width at the anterior end of the costal margin is just under one-half the length of the sternum. The sterno-coracoidal process is broad and short and flares out laterally in a low wide 'U' (Fig. 13A). The long coracoidal sulci are separated by a very short doubled dorsal manubrial spine; the ventral manubrial spine is lacking. The costal margin is long. The posterior lateral process is of medium length and width as the sternal notch extends about one-third the length of the sternum. The sternal plate and xiphial area are relatively wide. The anterior carinal margin is slightly concave, and the carinal apex is deep, just under one-half the length of the carina. The ventral margin of the carina slopes gradually upward toward the posterior tip of the sternum. The curvature in the carina (seen in ventral view) appears to be the result of preparation.

TURNIX

The sternum of *Turnix* (Figs. 11 and 13B) is quite narrow relative to its length; the width at the anterior end of the costal margin is just over one-fifth the length of the sternum. The sterno-coracoidal process is narrow and long and flares out laterally in a high, narrow 'U' (Fig. 13B). The short coracoidal sulci are separated by a long, narrow dorsal manubrial spine which has a very slight notch at its tip. A long lateral groove exists in the dorsal manubrial spine into which fits the medial edge of the coracoid. The costal margin is very short and crowded onto the base of the sterno-coracoid process. The posterior lateral process is very long and narrow as the sternal notch extends well over one-half the length of the sternum. The posterior lateral process terminates in a distinct downward curving tip. The sternal plate and xiphial area are quite narrow. The carina is similar to that in *Pedionomus*, the curvature again resulting from preparation.

ORTYXELOS

With a few exceptions, the sternum of *Ortyxelos* (Figs. 12 and 13C) is similar to that of *Turnix*. The dorsal manubrial spine is short with a distinct groove at its tip; it lacks the lateral groove. The ventral manubrial spine is long and narrow. The posterior lateral process curves inward at its extremity and lacks a distinct tip. The tip of the xiphial area is expanded into a small knob.

Comparison

The main difference between *Ortyxelos* and *Turnix* is in the shape of the manubrium in which they are radically different. The sternum of *Pedionomus* is broader than that of *Turnix* with a shorter sternal notch and with a shorter sterno-coracoidal process and a shorter dorsal manubrial spine. The wider sternum in *Pedionomus* indicates larger flight muscles. The difference in the coracoidal sulcus and surrounding processes is reflected in the ventral end of the coracoid.

PECTORAL GIRDLE

PEDIONOMUS

Coracoid: The coracoid of *Pedionomus* (Fig. 14B) is slightly shorter than that of *Turnix*. Its ventral half is flat with elongated pointed processes flaring to each side. The sternal facet extends from the tip of the internal distal angle to the tip of the ventral process. The internal distal angle is the bluntest of the ventral processes and lies behind the dorsal manubrial spine. The sterno-coracoid process lies outside and covers most of the sterno-coracoid process of the sternum. The procoracoid is separated from the brachial tuberosity by a broad gap which forms the major part of the triosseal canal. The scapular facet is a distinct round hollow, whereas, the furcular facet is a flat indistinct area. The large glenoid facet lies just over the scapular facet.

Furcula: The two clavicles form a wide 'U'-shaped furcula (Fig. 15C) corresponding to the wide sternum. The furcular process is minute, almost non-existent. A long scapular tuberosity encloses the triosseal canal and attaches to a shallow groove on the medial surface of the scapula.

Scapula: The blade of the scapula (Fig. 16C) is long and slightly decurved toward a blunt apex. Its glenoid facet is small and lies just lateral to the coracoid articulation. A shallow groove on the medial anterior surface articulates with the clavicle. The acromion is a short, wide, blunt process.

TURNIX

Coracoid: The slightly longer and stouter coracoid of *Turnix* (Fig. 14C) has a curved ventral half with a long, deep concavity on its posterodorsal surface. The sternal facet is short and curved, with the internal distal angle lying in the lateral groove of the dorsal manubrial spine. The sterno-coracoid process is short, but still overlies the corresponding process on the sternum. The procoracoid is fused to the brachial tuberosity (not complete in all specimens, e.g. *T. pyrrhothorax*) and, hence encloses the triosseal canal. A deep oblong scapular facet is present, but the furcular facet is flat and indistinct. The glenoid fossa lies just over the scapular facet.

FURCULA: The clavicles form a narrow 'U'-shaped furcula (Fig. 15B) corresponding to the narrow sternum. The furcular process is a flat, backwards-extending plate that almost reaches the carinal apex. No scapular tuberosity exists as the clavicle articulates only with the coracoid.

SCAPULA: The blade of the scapula (Fig. 16A) is long and decurves to a slightly expanded apex. The glenoid fossa is larger and lies lateral to the elongated slender acromion.

ORTYXELOS

CORACOID: The coracoid of *Ortyxelos* (Fig. 14A) is very similar to that of *Turnix* but the concavity on the posterodorsal surface is even deeper. A longer, truncated sterno-coracoid process appears to lie anterior to the corresponding process of the sternum. A gap separates the procoracoid and brachial tuberosity.

FURCULA: The furcula (Fig. 15A) is narrow with a flat furcular process similar to that in *Turnix*.

SCAPULA: The scapula (Fig. 16B) is similar in all respects to that of *Turnix*; the posterior end was damaged but appears to be somewhat expanded.

COMPARISON

Except for minor differences, the pectoral girdle of *Ortyxelos* is similar to that of *Turnix*. The entire ventral half of the coracoid in *Pedionomus* is radically different from that in *Turnix* corresponding to the difference in coracoidal sulcus. The deep posterior concavity in *Turnix* may also be related to the short coracoidal sulcus and a resulting curvature of the coracoid about its longitudinal axis. The long sulcus in *Pedionomus* may allow a flattened coracoid without a posterior concavity. However, the differences in the head of the coracoid are minor, limited mainly to the procoracoid brachial tuberosity connection. The wide furcula in *Pedionomus* as compared to the narrow furcula in *Turnix* reflects the difference in width of the sternum.

Basically, the entire suite of differences in the sternum and pectoral girdle of *Pedionomus* and *Turnix* are associated with a wide versus narrow sternum, and presumably, rib cage, in these two forms.

PECTORAL LIMB

PEDIONOMUS

HUMERUS: The humerus of *Pedionomus* (Fig. 17D) is long and slender, being one-third or more longer than the humerus of a *Turnix* of the same body size. Its head is a high dome with a distinct ligamental furrow running across its palmar surface. The external tuberosity is a slight shoulder on the humeral head just proximal to the low deltoid crest. The deltoid crest projects perpendicularly next to the shallow bicipital furrow, and lacks any overhang. The bicipital crest arises from the shaft in a gradual curve. Its pneumatic fossa is small and shallow and lacks a pneumatic foramen. The internal tuberosity is a distinct knob separated from the humeral head by a deep capital groove. The capital groove opens onto the anconal surface of the shaft and is separated from the pneumatic fossa by a well-developed medial crest of the pneumatic fossa. On the anconal surface, the external tuberosity is a mere shoulder on the head with a faint pectoral attachment in its centre. The shaft is very slightly bowed. On the distal anconal surface, the tip of the ectepicondylar prominence may be just seen. The ectepicondyle and the inner condylar ridge are small, subequal, parallel ridges, separated by a shallow external tricipital groove. The external condyle cannot be seen in the anconal view. The olecranal fossa is broad and shallow, but distinct, with a shallow internal tricipital groove leading into it. The low internal trochlear condyle lies just distal to the olecranal fossa. The shaft curves out gently to the small rounded entepicondyle. The distal condyles lie on the same plane except for the internal condyle which projects slightly beyond the others. On the palmar surface the tip of the ectepicondylar prominence makes a sharp corner with the margin of the shaft; the prominence lies well above the large external trochlear condyle. This condyle lies at a 30° angle to the longitudinal axis of the shaft and its proximal end continues smoothly into the ectepicondyle. A wide, shallow intercondylar furrow separates the external and internal condyles. The rounded internal condyle and smaller entepicondyle project slightly beyond the external condyle. The small entepicondylar prominence is overshadowed by the more proximal attachment of the anterior articular ligament. The attachment of the pronator brevis is a minute projection on the internal margin of the shaft. A large, clear depression of the brachialis anticus lies on the internal half of the shaft.

Radius and Ulna: The radius and ulna of *Pedionomus* (Fig. 19B) are slightly longer than the humerus and are one-third to one-half longer than the corresponding bones in a *Turnix* of the same body size. The olecranon of the ulna is very small and short. The internal and external cotylae of the ulna lie on the same plane and face proximally. The shaft of the ulna curves slightly. The internal distal condyle is large, projects distally and has a slight medial depression; hence, it appears to have two parallel ridges. The external condyle is small and proximal to the internal distal condyle. Most of these condyles and their detailed structure cannot be seen on the figures.

Carpometacarpus: Only the metacarpals II and III of *Pedionomus* (Fig. 20A) are shown to illustrate the length of the carpometacarpus; again it is about one-half again the length of this bone in a *Turnix* of the same body size. The extensor process is high and does not slant proximally. Metacarpal III is straight and lies close to metacarpal II; hence, the intermetacarpal space is narrow.

TURNIX

Humerus: The humeri of several species of *Turnix* are shown in Figs. 17A, 17C and 18. *Turnix nigricollis* and *T. suscitator* are about the same body size as *Pedionomus*, whereas *T. varius* is about twice as large as *Pedionomus*. The humeral head is a lower, rounded dome with a very faint ligamental furrow on its palmar surface. The deltoid crest arises next to the faint bicipital furrow and has a sharp inward overhang. The bicipital crest curves sharply from the shaft and is much larger than in *Pedionomus*. Its entire anconal surface is occupied by an enormous pneumatic fossa that penetrates to the tip of the humeral head; however, no pneumatic foramen is present. The internal tuberosity lies perpendicular to the longitudinal axis of the bone across the proximal margin of the pneumatic fossa. The relatively shallow capital groove parallels the internal tuberosity and separates it from the humeral head. A distinct medial knob blocks the opening of the capital groove to the anconal surface. The external tuberosity is large with a huge groove for the pectoral attachment. The entire proximal head of the humerus curves internally much more than in *Pedionomus*. On the distal anconal surface, the tip of the large, pointed ectepicondylar prominence may be seen. The condyles are similar to those seen in *Pedionomus* but with the internal trochlear condyle and the entepicondyle projecting distally more and the entepicondyle flaring much more to the side. The olecranial fossa is very wide, but quite faint. On the palmar surface, the projecting ectepicondylar prominence lies well proximal to the condyles. The large external condyle appears to be double and extends proximally to the internal trochlear condyle; a narrow, deep intercondylar furrow separates the two condyles. The large rounded internal condyle and the entepicondyle lie on the same plane. A distinct attachment for the anterior articular ligament is present, and a clear impression for the brachialis anticus occurs in some forms (Figs. 17A).

Radius and Ulna: The radius and ulna of *Turnix* (Fig. 19A) are bowed much more than those of *Pedionomus*. The olecranon is large and projects proximally with the internal cotyla facing anteriorally. The external cotyla is wide and lies distal to the internal cotyla. The internal distal condyle is large and has a medial depression. The external condyle is small, elevated and separated from the internal condyle by a deep groove. Again, most of the details of these condyles cannot be seen on the figure.

Carpometacarpus: Only the metacarpals II and III of *Turnix* (Fig. 20B) are figured to show their relative shortness. The extensor process is low and projects proximally. Metacarpus III is bowed outward so that the intermetacarpal space is wide.

ORTYXELOS

Humerus: The humerus of *Ortyxelos* (Fig. 17B) is basically like that of *Turnix*, but with some clear differences. The humeral head is a high dome with a most indistinct ligamental furrow. The deltoid crest does not have a medial overhang. The bicipital crest curves out sharply from the shaft and has a large deep pneumatic fossa which does not penetrate into the humeral head as far as in *Turnix*. The internal tuberosity and deep capital groove are like those in *Turnix* with an abrupt medial knob blocking the opening of the capital groove onto the shaft. The distal condyles are very much as those in *Turnix*, except that the ectepicondylar prominence is a narrow projection from the shaft.

Radius and Ulna: The radius and ulna of *Ortyxelos* (Fig. 19C) are similar to those of *Turnix*. The external cotyla appears to be slightly smaller, however.

Comparison

The wing bones of *Ortyxelos* are similar to those of *Turnix* except for a few characteristics; namely, the absence of the medial overhang on the deltoid crest and the fact that the cavity of the pneumatic fossa stops short of the humeral head.

Pedionomus, on the other hand, differs considerably from *Turnix* in the structure of the wing skeleton. All of the bony elements in the wing of *Pedionomus* are one-third to one-half longer than the comparable elements in a *Turnix* of the same body-size, resulting in a wing that is remarkably long for a cursorial bird. The entire head of the humerus differs in the two birds, the important points being the smaller less flaring bicipital crest and small pneumatic fossa, lack of a medial overhang on the deltoid crest, deeper ligamental furrow on the palmar surface of the humeral head, smaller internal tuberosity, absence of a medial knob at the opening of the capital groove and smaller external tuberosity and pectoral attachment in *Pedionomus*. The differences in the distal end of the humerus are less marked and are comprised mainly of the smaller ectepicondylar prominence, more distinct olecranial fossa, smaller and less projecting internal condyle and entepicondyle with the latter not flaring out from the shaft of the humerus, and a shallower wider intercondylar furrow in *Pedionomus*. The radius and ulna of *Pedionomus* are straighter with a smaller, shorter olecranon and smaller, coplanar internal and external cotylae with the latter not flaring as far from the shaft. The extensor process of the carpometacarpus in *Pedionomus* is higher and does not project proximally, and the metacarpal III is straight and lies close to the metacarpal II resulting in a narrow intermetacarpal space. The longer wings of *Pedionomus* may be correlated functionally with its broader sternum and presumably larger flight muscles.

SYNSACRUM

PEDIONOMUS

The synsacrum of *Pedionomus* (Fig. 21) is broad and flat. The foramina between the vertebrae may be simply the result of immaturity and incomplete ossification. The anterior blade of the ilium spreads out laterally in a flat curve. The posterior iliac plate is flat and terminates in a short posterior projection. The posterior iliac projection marks the termination of the iliac crest. When viewed from above or below, posteromedial margin of the synsacrum forms a wide shallow 'U'. The ischium extends posteriorally beyond the ilium and terminates in a narrow angle. The antitrochanter is small as is the pectineal process which is reduced to a mere corner at the anterior tip of the pubis. The pubis is narrow and flares widely to the side; in one specimen the posterior tip of the pubis curves slightly medially.

TURNIX

The synsacrum of *Turnix* (Fig. 22) is narrower and slightly deeper than that of *Pedionomus*. The anterior blade of the ilium drops vertically from the anterior iliac crest, and then spreads laterally; the anterior part flares out just before the anterior margin. The posterior iliac plate terminates in a minute process so that the posteromedial margin of the synsacrum is straight. A short, heavy process is present at the midpoint of the posterior iliac crest. The broad ischium extends posteriorally beyond the ilium and terminates in a broad, inward-curving angle. The pubis is broad and curves inward. The antitrochanter is large, and while the pectineal process is larger than in *Pedionomus*, it is still small.

ORTYXELOS

The synsacrum of *Ortyxelos* differs from that of *Turnix* only in that it lacks the heavy spine on the posterior iliac crest and the posterior iliac plate ends in a blunt projection.

COMPARISON

The major difference in the synsacrum of *Pedionomus* and *Turnix* is its greater width in *Pedionomus* with the posterior projections of the ischium and pubis flaring widely to the side. The ilium of *Pedionomus* has a prominent posterior projection that is absent in *Turnix*. The posterior iliac crest of *Pedionomus* is not as sharp and lacks the heavy process found in *Turnix*. The broad synsacrum of *Pedionomus* may be functionally or developmentally correlated with the broad sternum and pectoral girdle although the available evidence for such a correlation is meagre.

PELVIC LIMB

PEDIONOMUS

FEMUR: The head of the femur in *Pedionomus* (Fig. 23B) curves inwards from the shaft with a flat neck and iliac facet. The trochanter is well-developed and meets the iliac facet at a right angle. The obturator ridge is rather faint as is the trochanteric ridge. On the distal end of the bone, the internal condyle is flat and elevated above the external and fibular condyles; the intercondylar fossa is wide and shallow as is the popliteal area. The external and fibular condyles are subequal in size and are separated by a shallow fibular groove. On the anterior surface, the external and internal condyles are separated by a wide rotular groove. Considerable variation in length exists in the available specimens with the longest femur being 20% longer than the length of the shortest femur; the shortest femur is figured.

TIBIOTARSUS AND FIBULA: The tibiotarsus of *Pedionomus* (Fig. 24) is straight and over one-half again as long as the femur; that the fibula, in the present case, is quite short is considered to be the result of preparation since it extends about halfway down the tibio-tarsus in N.M.V. specimen No. B8872. The same variation in size exists in the tibiotarsus as in the femur; the shortest tibiotarsus is figured. The larger inner cnemial crest is a rounded plate, whereas the outer cnemial crest terminates in a distally projecting spine. The proximal articulating surfaces form a flat surface. As seen in posterior view, the internal and external distal condyles are subequal in size and separated by a broad intercondylar sulcus. The internal ligamental prominence curves smoothly from the shaft. On the anterior surface, the internal condyle projects anterior to the somewhat larger external condyle; the two condyles are separated by a broad anterior intercondylar fossa. In side view, the internal condyle has a distinct distal projection while the external condyle is almost circular. The supratendinal bridge is displaced toward the internal condyle. The tendinal groove is short and shallow.

TARSOMETATARSUS: The tarsometatarsus of *Pedionomus* (Fig. 26A) is the same length as the femur. The same range in size exists in the tarsometatarsus as in the femur and tibiotarsus; the middle-sized tarsometartarsus is figured. The proximal articulation is flat with the internal and external cotylae subequal in size and separated by a projecting intercotylar area. The hypotarsus comprises four tendinal canals and corresponding calcaneal ridges. Small inner and outer proximal foramina are present in a shallow anterior metatarsal groove; no posterior metatarsal groove exists. The distal foramen terminates a broad, shallow outer extensor groove. The trochlea for digit 2 is the most elevated one, is slightly posterior with a small wing and is separated from the trochlea for digit 3 by a wide internal intertrochlear notch. The trochlea for digit 3 projects the most distally and is the largest trochlea. The trochlea for digit 4 is elevated, but not as much as the trochlea for digit 2 and is separated from the trochlea for digit 3 by a narrow external intertrochlear notch. A very faint metatarsal facet exists on the ridge leading to the trochlea for digit 2 (not evident on the figure).

TURNIX

FEMUR: The femur of *Turnix* (Fig. 23A) is similar in size and structure to that of *Pedionomus*. It differs mainly in being straighter.

TIBIOTARSUS AND FIBULA: The tibiotarsus and fibula of *Turnix* (Fig. 25) are similar in size and most details of structure to those of *Pedionomus*. The distal projection on the internal condyle of *Turnix* is smaller than that of Pedionomus.

TARSOMETATARSUS: The tarsometatarsus of *Turnix* (Fig. 26B) is slightly shorter than that of *Pedionomus* but is similar in structure except for the lack of the metatarsal facet.

ORTYXELOS

The bones of the hind limb in *Ortyxelos* are very similar to those in *Turnix*.

COMPARISON

The hind limb is the most uniform part of the skeleton in *Pedionomus, Turnix* and *Ortyxelos*, the greatest difference being the presence of a hallux in *Pedionomus*.

Discussion

The description and comparison of the skeletons of *Pedionomus, Turnix* and *Ortyxelos* prompt some statements on the taxonomic relationships of these birds, and on some general problems such as the definition and recognition of palatal and nostril types. Each of these topics will be discussed in turn.

THE TURNICIDAE

On the basis of our comparisons of the skeletons of *Turnix* and of *Ortyxelos* with one another and more informally with members of the Charadriiformes, we concur completely with Lowe's (1923) conclusion that these birds are closely related. We share his surprise that *Ortyxelos* was separated from *Turnix* and placed in the Glareolidae, and would cite this earlier conclusion as an excellent example of the dangers in basing taxonomic decisions upon an inadequate study of characters.

All specimens of *Turnix* are quite uniform in the studied osteological features and differ from *Ortyxelos* in a few such as the complete absence in *Ortyxelos* of the posterior condyle of the quadrate, the lack in *Ortyxelos* of the bars connecting the vomer with the palatines, the radical difference in the shape of the manubrium of the sternum, and in a few aspects in the head of the humerus. These osteological differences in conjunction with plumage differences are sufficient to warrant the accepted generic distinction between these taxa. But, no matter what final decision is reached concerning the taxonomic distinction between *Turnix* and *Pedionomus*, *Ortyxelos* must remain in the same family-level taxon containing *Turnix*. Even if *Pedionomus* proves to be widely separated from *Turnix*, no justification exists for separating *Ortyxelos* and *Turnix* as distinct subfamilies.

TURNIX AND *PEDIONOMUS*

Interpretation of the comparisons of the skeletons of *Pedionomus* and *Turnix* (and *Ortyxelos*; in the following discussion, we include *Ortyxelos* under the term *Turnix*) is far more difficult. It is certainly not valid to regard *Pedionomus* simply as a slightly differently plumaged *Turnix* with a hallux. The osteological differences between these genera include many features of the skull and lower jaw, sternum and pectoral girdle, wing and synsacrum. Only in the elements of the leg are these genera similar to one another. These genera can be distinguished and recognized from one another with greater ease than can many families of non-passerine birds. One may argue with ease that differences are far easier to recognize between small taxa than between taxa with many members. And the observed differences must be analyzed functionally and taxonomically, neither of which can be done properly at this time.

So little is known about the habits of *Pedionomus* at this time that the functional significances of the observed morphological differences could only be guessed, and with rather wild guesses. We propose only to point out some of the possible functional units and group the different features into these larger complexes. The set of differences in the skull and mandible would constitute at least one major functional complex distinct from all other complexes of the skeleton. However, it is not possible to distinguish between functional units within the skull at this time, although some of the differences do not appear to be closely related functionally. The whole set of differences in the sternum, pectoral girdle and possibly even the synsacrum may all be closely related and may be associated with a general broadening of the entire body skeleton of *Pedionomus* relative to the narrow skeleton of *Turnix*. (Or the body skeleton of *Turnix* may have become narrower.) These features are almost certainly not all correlated functionally, but may be parts of a large developmental complex involving the entire trunk skeleton. The details of the argument supporting this suggestion will be outlined step by step.

The elongated wing bones in *Pedionomus* and the suite of differences in the humerus would constitute a functional complex; the function and the adaptive significance of longer wings in *Pedionomus* are obscure at best. The longer wings may require stronger flight muscles which would influence the configuration of the sternum and pectoral girdle. Thus the complex of wing bones may be closely related with the elements of the sternum and pectoral girdle, and indeed the wing, pectoral girdle and sternum may constitute a single large functional complex. The selection forces acting upon the different characteristics of flight in *Turnix* and *Pedionomus* would act upon this entire complex. These selection forces would favour the longer wings in *Pedionomus*, the required larger flight muscles and hence the broadened sternum and pectoral girdle. As mentioned above, many of the detailed differences in the pectoral girdle and sternum appear to be associated with a general broadening of this part of the skeleton. Broadening of the pectoral girdle and sternum may have occurred by selection favouring a general broadening of the growth field controlling this part of the skeleton. Or, quite possibly, broadening of the anterior half of the trunk skeleton may have occurred by modification of a growth field that controlled the width of the entire trunk skeleton. Hence selection for a different flight pattern requiring larger flight muscles in *Pedionomus* would result in a broader synsacrum simply because this element is part of the trunk skeleton under the control of the broadening growth field being favoured by selection. This line of argument follows that proposed by Davis (1964, 1966) in his explanation of growth-related features in which an adaptive modification in one feature resulted in changes in many other features for which no functional and adaptive explanation could be offered.

It is possible that the whole suite of skeletal differences between *Pedionomus* and *Turnix* may be reduced to major differences in the set of features comprising the cranial functional unit and in the set of bony elements comprising the flight functional unit and the trunk developmental complex. We do not condense the many differences between *Turnix* and *Pedionomus* as a means of underestimating the dissimilarites between these taxa, but present this discussion to prevent a simple tabulation of all the described differences between these genera. Such a tabulation would result in redundant listing of the same difference under different features and in a great overestimation of the distinction between these genera. In conclusion we would like to emphasize that if the total differences between *Pedionomus* and *Turnix* prove to be modifications in the two functional units of the cranium and the flight apparatus, these modifications would be major ones that cannot be treated casually.

The taxonomic implications of these osteological comparisons of *Turnix* and of *Pedionomus* are equally difficult to assess because of our limited comparative base. These genera share many points of similarity and are probably members of a monophyletic taxon but the taxonomic rank of this taxon and whether any other genera or families of birds should be included are still open to question. It does seem reasonable to retain the generally accepted suborder Turnices within the Gruiformes for *Turnix, Ortyxelos* and *Pedionomus*. Yet we have little evidence from our study to support the inclusion of the Turniees in the Gruiformes. Within the Turnices, *Turnix* and *Pedionomus* have been distinguished on the familial and subfamilial levels. Interpretation of our evidence could support either position as well as considering these genera as members of distinct superfamilies. If all the differences are tabulated, the list becomes quite impressive and would support a conclusion that *Pedionomus* and *Turnix* belong to different superfamilies, or may not even be related at all but have converged toward each other in size and habits. We should point out that earlier systematists have allied *Turnix* with the galliform birds, perhaps being misled by the convergent similarity between *Turnix* and *Coturnix* of the Phasianidae. And *Ortyxelos* had been separated from *Turnix* and placed in a family belonging to a different order. At the other extreme, one could argue that many of the differences between *Turnix* and *Pedionomus* are all associated with modifications in either the cranium or the flight apparatus, the actual difference between the two genera being far less than the impressive list of individual differences. We are not prepared to defend either position at this time, nor do we wish to accept the easy compromise position. We do wish to emphasize that it is misleading to characterize *Pedionomus* as a *Turnix* with a hind toe. These genera are far more distinct, but may still prove to be members of the same family.

As a practical taxonomic solution, we would support the generally accepted position of placing *Turnix* and *Ortyxelos* in the Turnicidae and *Pedionomus* in the Pedionomidae, both families being included in the Turnices.

These equivocal taxonomic conclusions are far less than satisfactory but little more can be expected in the light of our very restrictive comparative base. Yet on the positive side are the facts that the comparisons do indicate strongly that *Turnix* and *Pedionomus* are more closely related to one another than to other gruiform birds, and that considerably more information is available with which to compare *Pedionomus* with other birds.

PNEUMATICY

A minor but interesting feature of the skeleton of these genera is that it appears to be completely non-pneumatic in that no foramen for air sacs could be found. For example, no pneumatic foramen is present in the humerus in spite of the extremely deep pneumatic fossa in *Turnix* and *Ortyxelos*.

PALATAL TYPES

The variation in the shape of the vomer in *Turnix* has an important bearing upon the concept of palatal types in birds and recent treatment (uses and abuses) of them. In Huxley's (1867) original description of palatal types in birds, he included the entire palate in his definition of each type. Shortly thereafter, attention was focused upon the condition of the vomer and maxillopalatines which became the important and usually sole criterion for each palate type. Hence, the major hallmark for the aegithognathous palate is a broad vomer with a truncated anterior margin, whereas for the schizognathous palate it is the narrow vomer with a sharp pointed anterior tip. These simplified criteria omit many of the basie aspects of the palatal types used by Huxley. More significantly, they permit erroneous recognition of palates corresponding to each type and lead to serious misconceptions of the possible affinities of some birds and of the value of palatal types in classification of birds. On the basis of the shape of the vomer, the several species of *Turnix* (Fig. 7) range from a fairly typical schizognathous form to a fairly typical aegithognathous form. But if all the criteria cited by Huxley (1867: 426, 450-451) are used, the palates of *Turnix* as well as *Ortyxelos* and *Pedionomus* are clearly schizognathous. The broadening of the vomer and truncation of its anterior tip in some forms are part of a graded series of modifications in *Turnix* resulting in a broad truncated vomer in a few species. But this change is not toward the condition of the aegithognathous palate except in the shape of the vomer. Broadening the vomer could be associated simply with greater width of the skull or with increased need for support of the floor of the nasal cavity, and could have occurred independently several times among schizognathous birds.

Hence in spite of the broad, truncated vomer in several species of *Turnix*, we regard the palate of all members of the Turnices as schizognathous. We urge that Huxley's original criteria for palate types be followed carefully and that complete descriptions be given of any palates that may be mis-identified as the wrong type if the condition of the vomer and maxillopalatines are used as the only criteria.

Nostril Types

The nature of the nostrils in the Turnices posed a problem similar to that of the palate, namely they do not correspond exactly to the original descriptions. The original definition (Garrod 1873; and see Appendix 2) of the holorhinal versus the schizorhinal nostril is based upon the shape of the posterior end of the nostril (rounded versus a narrow slit) and the position of the posterior end of the nostril relative to the nasal-frontal hinge at the base of the upper jaw (anterior to the hinge versus posterior to the hinge). Hence, the original definition of the schizorhinal nostril indicates one possessing a narrow, slit-like posterior end that projects posteriorly beyond the nasal-frontal hinge. The slit-like posterior end became the criterion for the schizorhinal nostril while the rounded posterior end was used as the criterion for the holorhinal nostril.

The important functional differences between the holorhinal and schizorhinal nostrils are reflected in whether or not the nostril projects back beyond the nasal-frontal (kinetic) hinge of the upper jaw. The holorhinal nostril falls short of the nasal-frontal hinge and does not separate the hinge line of the lateral nasal bars from that of the medial dorsal bar (Bock 1964a). It is associated functionally with the prokinetic type of kinesis and with the ratite type of rhynchokinesis. The schizorhinal nostril projects back beyond the nasal-frontal hinge and separates the hinge line of the lateral nasal bars from that of the medial dorsal bar. It is associated functionally with the charadriiform type of rhynchokinesis. Whether the posterior end of the nostril is rounded or pointed does not influence in the least this functional consequence of the two nostril types. And the shape of the posterior end of the nostril does not have any independent functional significances.

Hence, the least important one of the two original criteria of the nostril types was chosen as the major and often sole criterion. We would recommend strongly that the distinction between the holorhinal and the schizorhinal nostril be based upon whether the posterior end of the nostril stops anterior to, or projects behind, the nasal-frontal hinge (i.e., separates the hinge of the medial dorsal bar from the hinge of the lateral nasal bars). The nostril of the Turnices is clearly schizorhinal because it projects well behind the nasal-frontal hinge in spite of the fact that its posterior end is rounded. The broad nostril with a rounded posterior end in these birds is correlated with the broadening of the anterior part of the skull, as in the Glareolidae (Bock 1964b). To designate the nostril of these birds as holorhinal or pseudoholorhinal because the posterior end of the nostril is rounded obscures the most important morphological and functional property of the nostril in these birds. The term pseudoholorhinal is best dropped from usage, or restricted strictly to those birds that possess a prokinetic skull as adults and a slit-like holorhinal nostril with indications that this prokinetic condition has evolved secondarily from a rhynchokinetic skull and the original schizorhinal nostril has been modified toward a holorhinal condition.

Summary

1. The skeleton of *Pedionomus* is described and compared with those of *Turnix* and *Ortyxelos*. *Turnix* and *Ortyxelos* are quite similar to one another in most features of their skeleton, but are quite different from *Pedionomus* in many characteristics of the skull, sternum, pectoral girdle, wing and synsacrum. Only the elements of the hind limb are similar in these genera. The cranial differences include a smaller ectethmoid, lack of an ossified alinasal, more robust palatines, larger maxillo-palatines, larger postorbital process and smaller zygomatic process in *Pedionomus*. The sternum, pectoral girdle and synsacrum of *Pedionomus* are considerably wider than the corresponding elements in *Turnix* with numerous differences in detail. All elements of the wing of *Pedionomus* are longer than those of *Turnix* with some striking differences in the head of the humerus.

2. The osteological evidence supports the current taxonomic status of *Turnix* and *Ortyxelos* as separate genera in the family of Turnicidae. *Pedionomus* is more distinct from these birds—it is not simply a *Turnix* with a hallux—but it is not possible to decide at this time the level of taxonomic distinctiveness of these birds. As a practical taxonomic conclusion, it is suggested that the general practice of placing *Pedionomus* in a separate family, the Pedionomidae, be maintained.

3. Several confusing points in the definitions of the schizognathous and aegithognathous palates and of the holorhinal and schizorhinal nostrils are discussed. It is concluded that the members of the Turnices possess a schizognathous palate and a schizorhinal nostril.

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Appendix 1

This paper provides a good opportunity to correct a series of inexcusable errors made by Bock concerning the names applied to the basipterygoid articulation and the basitemporal articulation which were brought to his attention several years ago by McEvey.

The basipterygoid articulation is between the pterygoid bone and the basipterygoid process on the basisphenoid rostrum. It is found in many groups of tetrapods and is sometimes called the basal articulation. In two earlier papers (Bock 1959, 1960) this articulation was called the basisphenoid articulation, a poor name but not entirely wrong. However, in later papers (Bock 1963, 1964b) this articulation was called the basitemporal articulation, the basipterygoid process called the basitemporal process and the basisphenoid rostrum called the basitemporal rostrum. These terms are absolutely wrong and probably arose because of a confusion between the several 'basi-' terms. In Bock (1964a: 5-6) and the present paper, the correct terms of basipterygoid process and basipterygoid articulation are used and should be followed.

The basitemporal articulation (or articular-basitemporal articulation) is between the internal (= medial) process of the mandible and some process on the basitemporal plate (Bock 1960); it is also called the secondary articulation of the mandible. The brace formed by these bones abutting against one another has been called the medial brace of the mandible (Bock 1959, 1960). In Bock (1964a: 9, 1964b: 393) and in the present paper this articulation is called the basitemporal articulation and/or the secondary articulation of the mandible; either term is acceptable, but the term basitemporal articulation can be used only for this structure.

Appendix 2

After the manuscript was completed, we checked the literature for the reference of the original description for the terms holorhinal and schizorhinal; these were proposed by Garrod (1873). Much to our surprise, we discovered that Garrod figured the skull of *Pedionomus torquatus* as one of his original examples of a schizorhinal bird (Fig. 7, p. 34), although he did not include this genus in his list of schizorhinal birds (pp. 36-37). Hence our statement that Gadow's study (1891) is the only anatomical study of this bird is in error. Gadow (1891) had also overlooked this figure for he states that no earlier anatomical work on *Pedionomus* exists and notes (p. 206), ‘Garrod does not mention it at all’. The specimen figured by Garrod is probably lost as we were unable to locate any skeletal material in British museums, nor did Gadow indicate the existence of any specimens other than the two sent to the Cambridge Museum of Zoology from Australia shortly before he undertook his study.

It may be noted that Garrod included the Turnicidae (presumably including *Pedionomus*), the Glareolidae, the Pteroclidae and the Columbae among his list of schizorhinal birds. He does not say whether he had been able to examine skulls of the Thinocoridae although he does include the Limicolae (excluding the Burhinidae) among the schizorhinal birds. Many of these birds are considered to be holorhinal by recent workers although we concur with Garrod's original interpretations.

Abbreviations Used in the Figures

SKULL

ab = auditory bulla
an = alinasal
ba = basipterygoid articulation
bsr = basisphenoid rostrum
bta = basitemporal articulation
btp = basitemporal plate
cpm = coronoid process of mandible
ect = ectethmoid plate
ectf = ectethmoid foramen
epm = external process of mandible
et = eustachian tube
fm = foramen magnum
ipm = internal process of mandible
ipp = interpalatine process
j = jugal bar
lbtp = lateral basitemporal process
lc = lateral condyle of quadrate
lnb = lateral nasal bar
lqf = lateral quadrate facet
mc = medial condyle of quadrate
mf = mandibular fossa
mp = maxillopalatine
mpp = mediopalatine process
mqf = medial quadrate facet
n = nostril
obp = orbital process of quadrate
ocp = occipital plate
os = orbital septum
otp = otic process of quadrate
p = palatine
pc = posterior condyle of quadrate
pmp = posterior meatic process
pp = postorbital process
ppb = prepalatine bar
ps = palatine shelf
pt = pterygoid
q = quadrate
rpm = retroarticular process of mandible
smf = suprameatic fossa
smp = suprameatic process
sr = supraorbital rims
tf = temporal fossa
v = vomer
zp = zygomatic process

STERNUM AND PECTORAL GIRDLE

acm = anterior carinal margin
acr = acromion
bt = brachial tuberosity
c = carina
cm = costal margin
cs = coracoidal sulcus
dms = dorsal manubrial spine
ff = furcular facet
fp = furcular process
gf = glenoid facet
ida = internal distal angle
pcc = posterior coracoidal concavity
plp = posterior lateral process
proc = procoracoid
scf = scapular facet
scp = sternocoracoidal process
scpc = sternocoracoidal process of coracoid
sf = sternal facet
sn = sternal notch
sp = sternal plate
st = scapular tuberosity
tc = triosseal canal
vms = ventral manubrial process
vp = ventral process
xa = xiphial area

PECTORAL LIMB

aal = attachment of anterior articular ligament
apb = attachment of the pronator brevis
bc = bicipital crest
bf = bicipital furrow
cg = capital groove
dba = depression brachialis anticus
dc = deltoid crest
ecc = ectepicondyle
ecp = ectepicondylar prominence
enc = entepicondyle
et = external tuberosity
etc = external trochlear condyle
etg = external tricipital groove
expm = extensor process of metacarpus
h = head of humerus
icf = intercondylar furrow
icr = inner condylar ridge

idc = internal distal condyle
ims = intermetacarpal space
it = internal tuberosity
itc = internal trochlear condyle
itg = internal tricipital groove
lf = ligamental furrow
m II = metacarpal II
m III = metacarpal III
mcp = medial crest of pneumatic fossa
mk = medial knob of humerus
of = olecranal fossa
ol = olecranon
pa = pectoral attachment
pf = pneumatic fossa
r = radius
u = ulna

SYNSACRUM

abil = anterior blade of ilium
ac = acetabulum
ant = antitrochanter
il = ilium
ilc = iliac crest
is = ischium
isa = ischial angle
pep = pectineal process
pilc = process of iliac crest
ppil = posterior projection of ilium
pu = pubis

PELVIC LIMB

aif = anterior intercondylar fossa
amg = anterior metatarsal groove
dmf = distal metatarsal foramen
ec = external condyle of femur
edct = external distal condyle of tibiotarsus
etn = external intertrochlear notch
fcf = fibular condyle of femur
fib = fibula
fig = fibular groove
hcr = hypotarsal calcaneal ridge
hf = head of femur
htc = hypotarsal tendinal canal
hyp = hypotarsus
icc = inner cnemial crest
icf = internal condyle of femur
ics = intercondylar sulcus
idct = internal distal condyle of tibiotarsus
ilf = iliac facet
ilp = internal ligamental prominence
inf = intercondylar fossa
itn = internal intertrochlear notch
mtf = metatarsal facet
nf = neck of femur
obr = obturator ridge
occ = outer cnemial crest
oeg = outer extensor groove
pa = popliteal area
peco = proximal external cotyla
pico = proximal internal cotyla
pmf = proximal metatarsal foramen
rg = rotular groove
stb = supratendinal bridge
td 2 = trochlea for digit 2
td 3 = trochlea for digit 3
td 4 = trochlea for digit 4
tng = tendinal groove
trf = trochanter of femur
trr = trochanter ridge
tt = tibiotarsus

Explanation of Text-Figures 1-26

FIG. 1—The skull and mandible of *Pedionomus torquatus*. The skull (N.M.V. W6698) is shown in dorsal view (A), lateral view (B) and ventral view (D), and the mandible is shown in lateral view (C). An isolated vomer (N.M.V. W6084) is shown in ventral view (E) at the same approximate size and anteroposterior position relative to the ventral view of the skull. The vomer may be slightly larger than correct relative size. The key to the abbreviations used in this and other figures will be found on pp. 209-210. Approximately 3½ times life size.

FIG. 2—The squamosal region of the skull of *Pedionomus torquatus* (N.M.V. W6084) to show the details of the articular facets for the quadrate and processes adjacent to the lateral quadrate facet. Approximately 17 times life size.

FIG. 3—The isolated vomer of *Pedionomus torquatus* (N.M.V. W6084) seen in ventral view (A) and dorsal view (B). The long articular grooves on the dorsal side of the posterior processes and their correspondence to the elongated anterior processes from the palatines (Fig. 1D) should be noted. Approximately 17 times life size.

FIG. 4—The skull and mandible of *Turnix nigricollis* (A.M.N.H. 5381). The skull is shown in dorsal view (A), lateral view (B) and ventral view (D), and the mandible is shown in lateral view (C). Approximately 4 times life size.

FIG. 5—The skull and mandible of *Turnix pyrrhothorax* (N.M.V. 665), the heaviest-billed species in the genus. The skull is shown in lateral view A) and ventral view (C), and the mandible is shown in lateral view (B). Note the depth of the mandibular ramus and the well developed coronoid process. Approximately 4 times life size.

FIG. 6—The skull of *Turnix varia* (A.M.N.H. 1601), one of the largest species in the genus, shown in lateral view. Approximately 3½ times life size.

FIG. 7—The vomer of several species of *Turnix*, seen in ventral view, to show the great range of variation and trend toward an aegithognathous-like vomer in the extreme case. The species shown are: (A) *T. sylvatica* (U.S.N.M. 429078); (B) *T. nigricollis* (A.M.N.H. 5381); (C) *T. tanki* (A.M.N.H. 1581); (D) *T. nigricollis* (A.M.N.H. 1994); (E) *T. sylvatica* (U.S.N.M. 344362); (F) *T. sylvatica* (U.S.N.M. 344365); (G) *T. varia* (A.M.N.H. 1601); and (H) *T. pyrrhothorax* (N.M.V. 665). Approximately 16 times life size.

FIG. 8—The cranial base and mandible of (A) *Turnix nigricollis* (A.M.N.H. 5381) and (B) *Pedionomus torquatus* (N.M.V. W6698) seen in ventral view. The mandible has been replaced upon its quadrate articulation so that its relationships to other parts of the skull may not be exactly correct. Note the basitemporal articulation between the internal process of the mandible and the lateral process of the basitemporal plate and the basipterygoid articulation between the pterygoid and the basipterygoid process of the braincase (see the discussion in Appendix 1). Approximately 7 times life size.

FIG. 9—The mandible of (A) *Turnix nigricollis* (A.M.N.H. 5381), (B) *Pedionomus torquatus* (N.M.V. W6698), and (C) *Turnix pyrrhothorax* (N.M.V. 665) seen in dorsal view to show the details of the articular surfaces. Approximately 6½ times life size.

FIG. 10—The sternum of *Pedionomus torquatus* (N.M.V. W6084) seen in dorsal view (A), lateral view (B), and ventral view (C). Approximately 3 times life size.

FIG. 11—The sternum of *Turnix nigricollis* (A.M.N.H. 5381) seen in dorsal view (A), lateral view (B), and ventral view (C). Approximately 3¾ times life size.

FIG. 12—The sternum of *Ortyxelos meiffrenii* (B.M.N.H. S/1952.2.71) seen in dorsal view (A), lateral view (B), and ventral view (C). Approximately 5 times life size.

FIG. 13—The sternum of (A) *Pedionomus torquatus* (N.M.V. W6084), (B) *Turnix nigricollis* (A.M.N.H. 5381), and (C) *Ortyxelos meiffrenii* (B.M.N.H. S/1952.2.71) seen in anterior view. Approximately 3½ times life size.

FIG. 14—The coracoid of (A) *Ortyxelos meiffrenii* (B.M.N.H. S/1952.2.71), (B) *Pedionomus torquatus* (N.M.V. W6084), and (C) *Turnix nigricollis* (A.M.N.H. 5381) seen in posterodorsal view (left figure) and anteroventral view (right figure). Approximately 3½ times life size.

FIG. 15—The furcula of (A) *Ortyxelos meiffrenii* (B.M.N.H. S/1956.2.1), (B) *Turnix nigricollis* (A.M.N.H. 5381), and (C) *Pedionomus torquatus* (N.M.V. W6698) seen in lateral view (left figure) and anterior view (right figure). Approximately 3 times life size.

FIG. 16—The scapula of (A) *Turnix nigricollis* (A.M.N.H. 5381), (B) *Ortyxelos meiffrenii* (B.M.N.H. S/1952.2.71), and (C) *Pedionomus torquatus* (N.M.V. W6698) seen in lateral view. Approximately 4½ times life size.

Fig. 17—The humerus of (A) *Turnix nigricollis* (A.M.N.H. 5381), (B) *Ortyxelos meiffrenii* (B.M.N.H. S/1956.22.1), (C) *Turnix suscitator* (U.S.N.M. 347288), and (D) *Pedionomus torquatus* (N.M.V. W6698) seen in anconal view (left figure) and palmar view (right figure). Approximately 3½ times life size.

Fig. 18—The humerus of *Turnix varia* (A.M.N.H. 1601) seen in anconal view (top figure) and palmar view (bottom figure). Approximately 3½ times life size.

Fig. 19—The radius and ulna of (A) *Turnix nigricollis* (A.M.N.H. 5381), (B) *Pedionomus torquatus* (N.M.V. W6655), and (C) *Ortyxelos meiffrenii* (B.M.N.H. S/1952.2.71) seen in ventral view. Approximately 3½ times life size.

Fig. 20— The carpometacarpus of (A) *Pedionomus torquatus* (N.M.V. W6084), and (B) *Turnix nigricollis* (A.M.N.H. 5381) to show the relative lengths of the main element. In *Pedionomus*, the left figure is the dorsal view and the right figure the ventral view. In *Turnix*, the left figure is the ventral view and the right figure the dorsal view. Approximately 4½ times life size.

Fig. 21—The synsacrum of *Pedionomus torquatus* (N.M.V. W6655) seen in dorsal view (A), lateral view (B), and ventral view (C). The ends of the pubis have been cut off to fit the drawings into one figure. Approximately 3 times life size.

Fig. 22—The synsacrum of *Turnix nigricollis* (A.M.N.H. 5381) seen in dorsal view (A), lateral view (B), and ventral view (C). Approximately 3½ times life size.

Fig. 23—The femur of (A) *Turnix nigricollis* (A.M.N.H. 5381), and (B) *Pedionomus torquatus* (N.M.V. W6698) seen in posterior view (left figure) and anterior view (right figure). Approximately 4 times life size.

Fig. 24—The tibiotarsus and fibula of *Pedionomus torquatus* (N.M.V. W6698) seen in (A) anterolateral, (B) posteromedial, (C) posterior, and (D) anterior views. Approximately 3½ times life size.

Fig. 25—The tibiotarsus and fibula of *Turnix nigricollis* (A.M.N.H. 5381) seen in (A) anterolateral, (B) posteromedial, (C) posterior and (D) anterior views. Approximately 3½ times life size.

Fig. 26—The tarsometatarsus of (A) *Pedionomus torquatus* (N.M.V. W6655), and (B) *Turnix nigricollis* (A.M.N.H. 5381) seen in anterior view (left figure) and posterior view (right figure). Approximately 5 times life size.

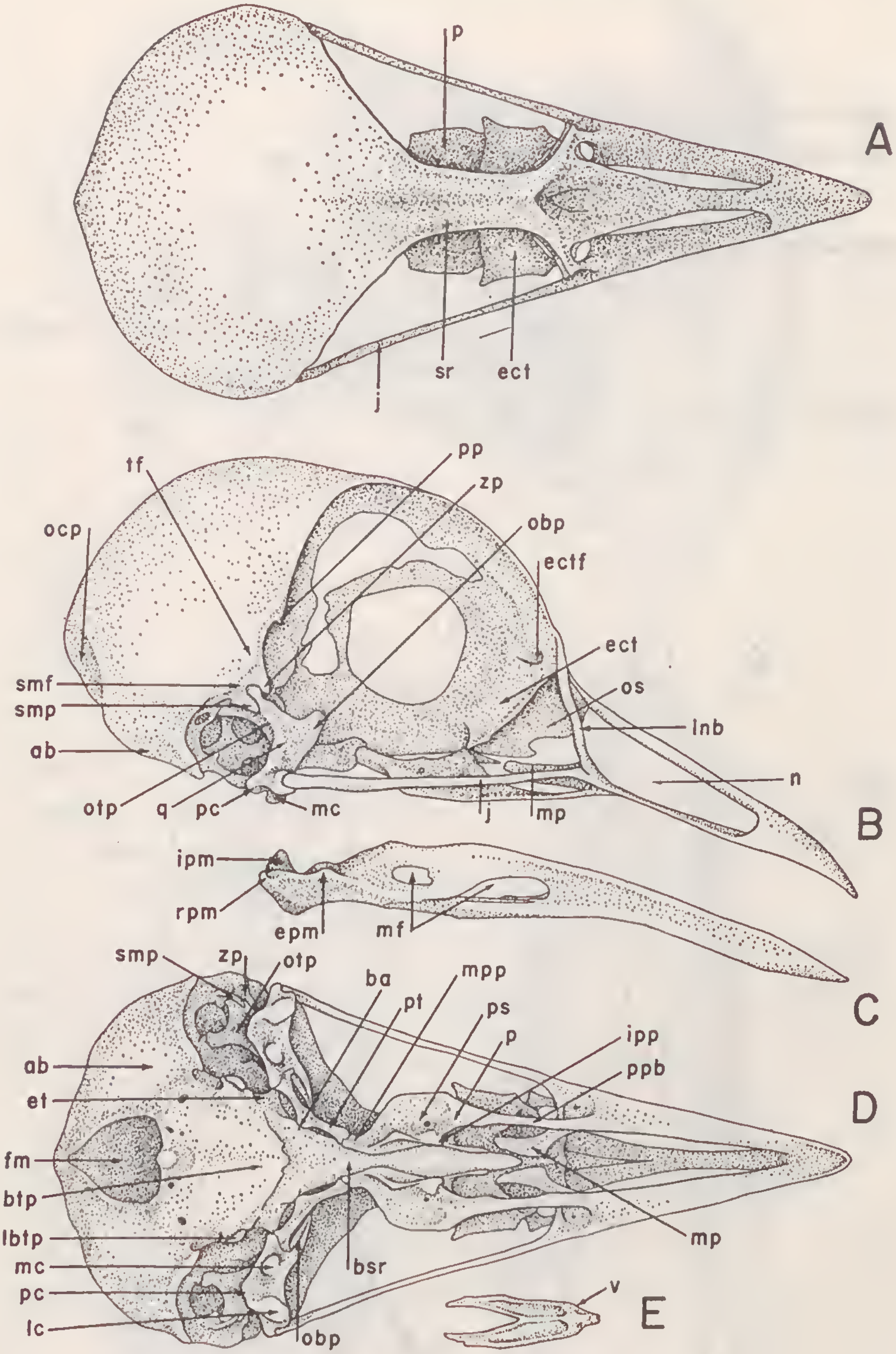
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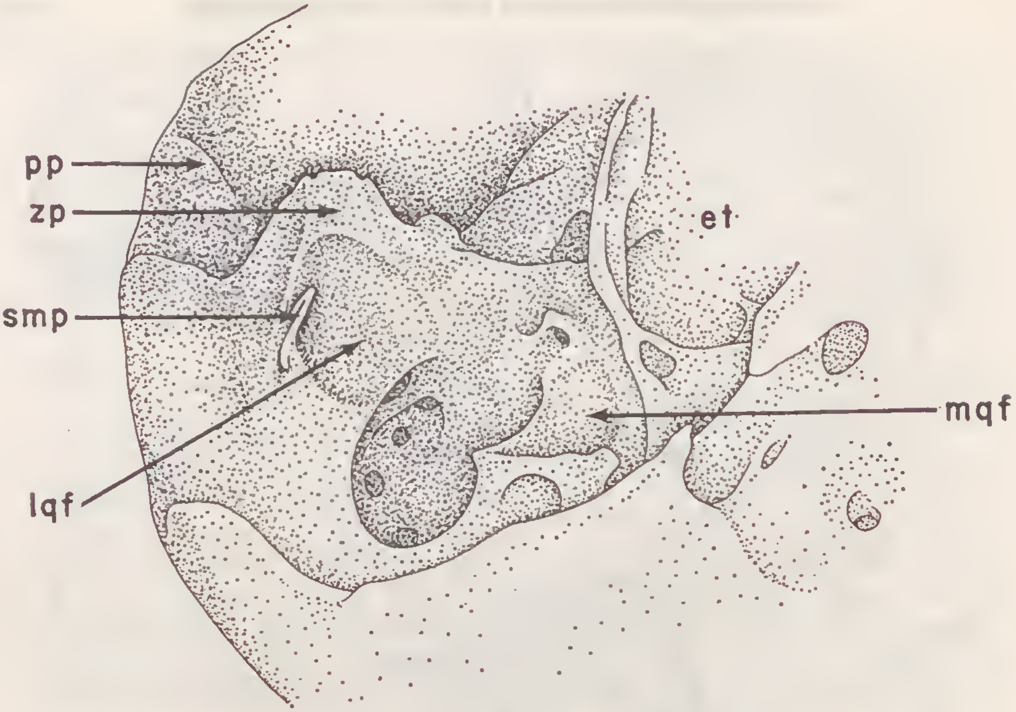
Fig. 1



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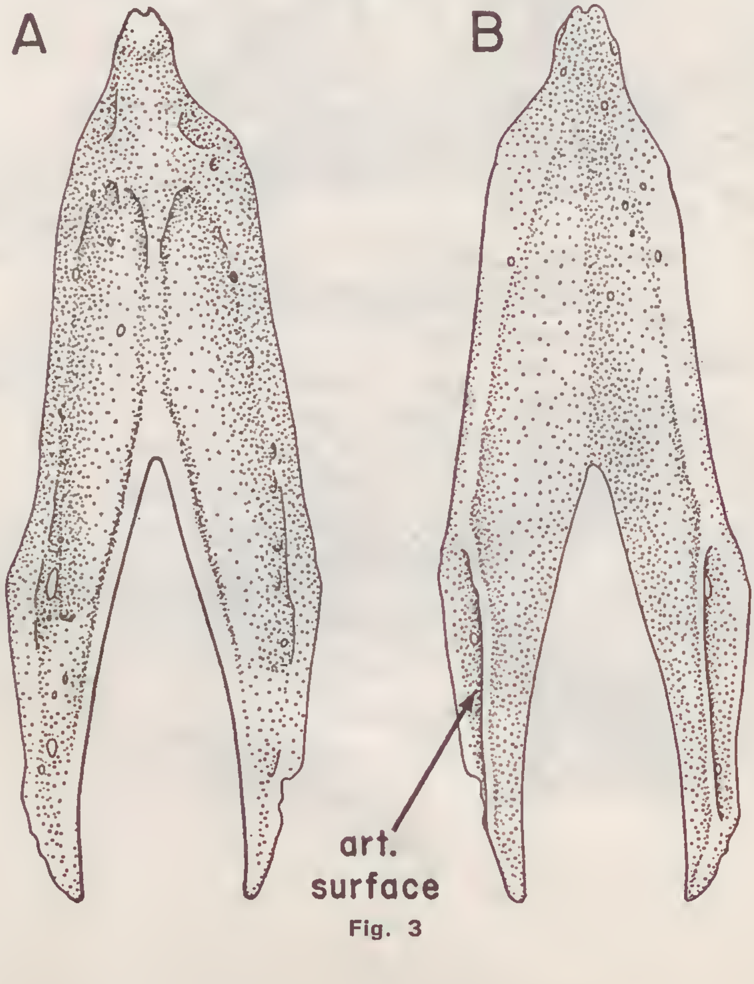

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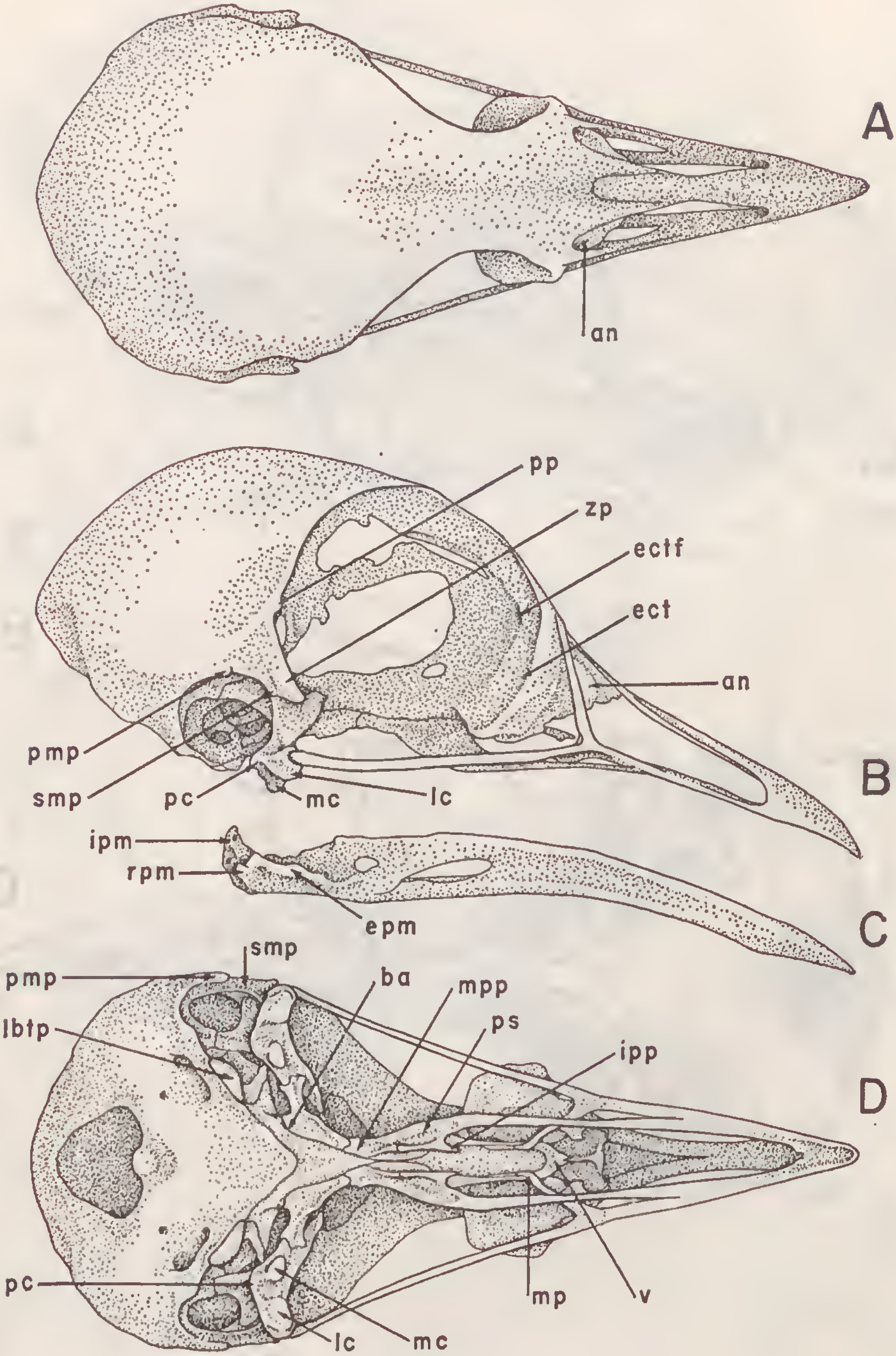
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Fig. 4

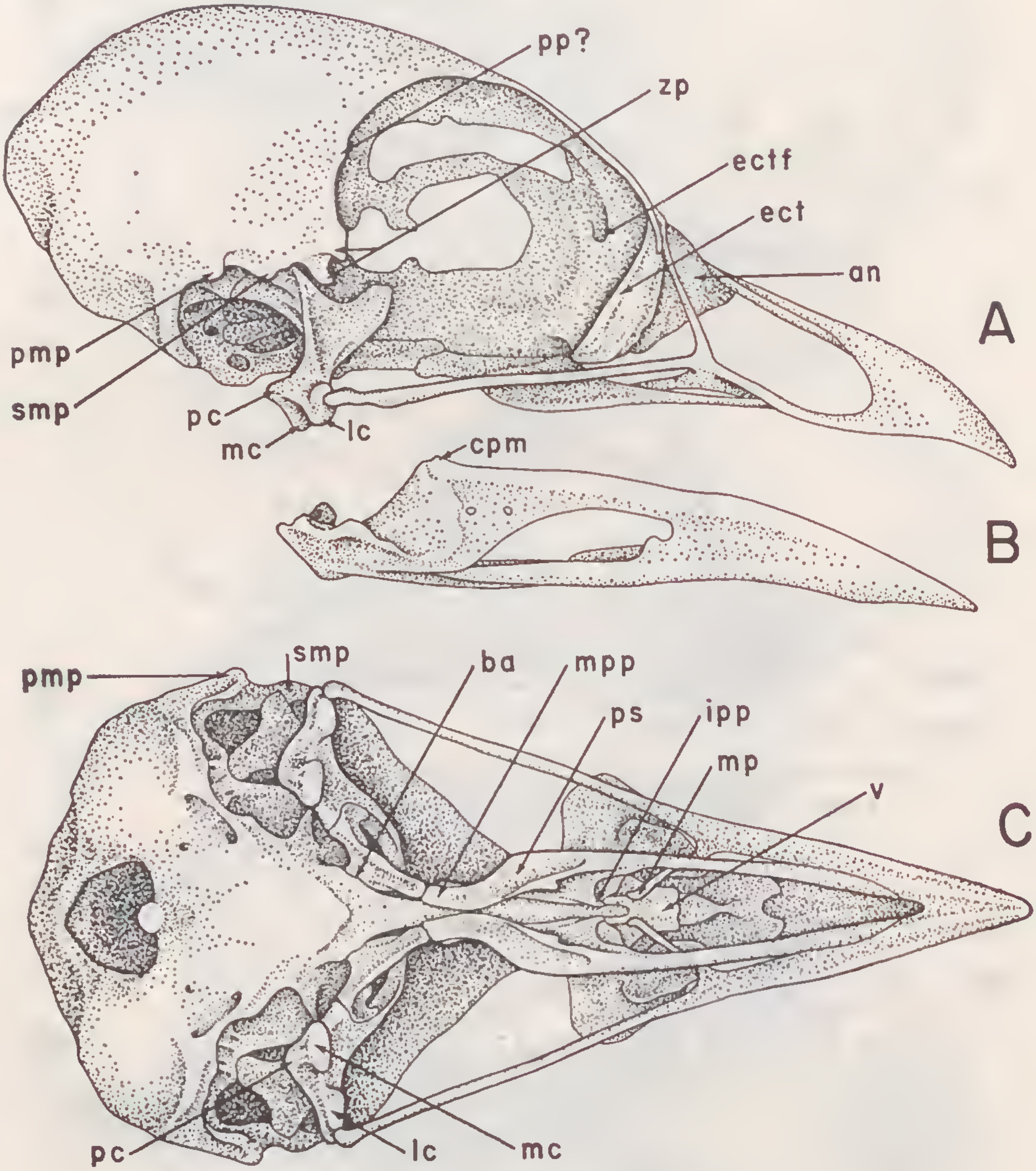
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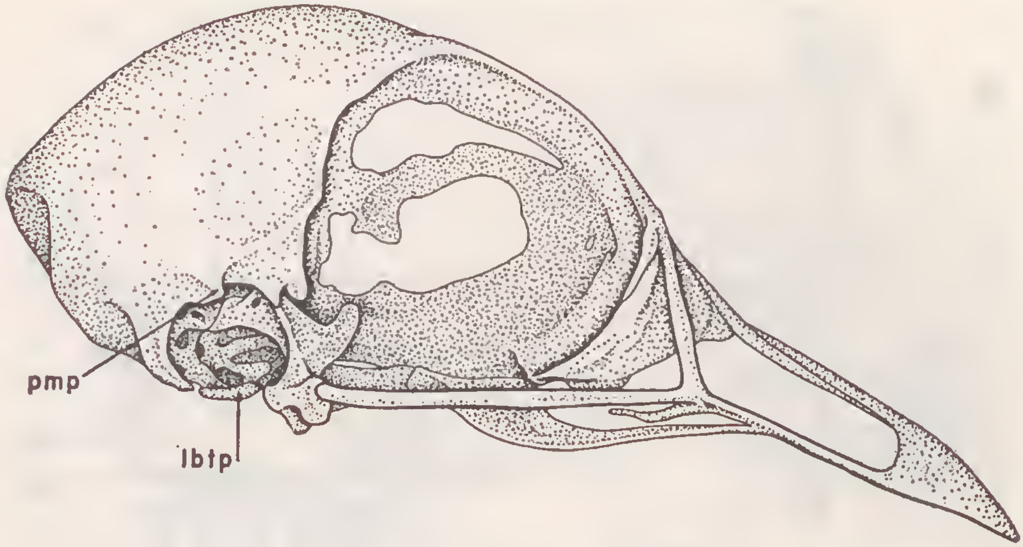
Fig. 5



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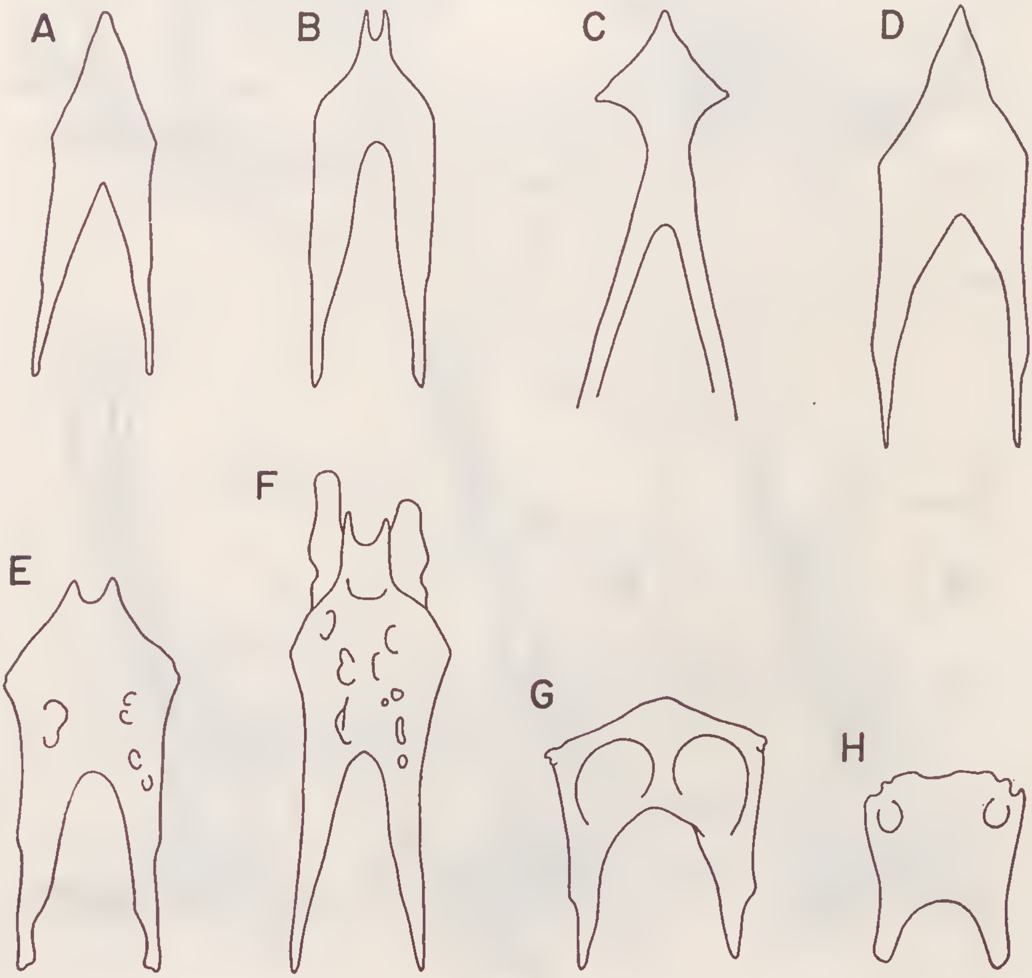

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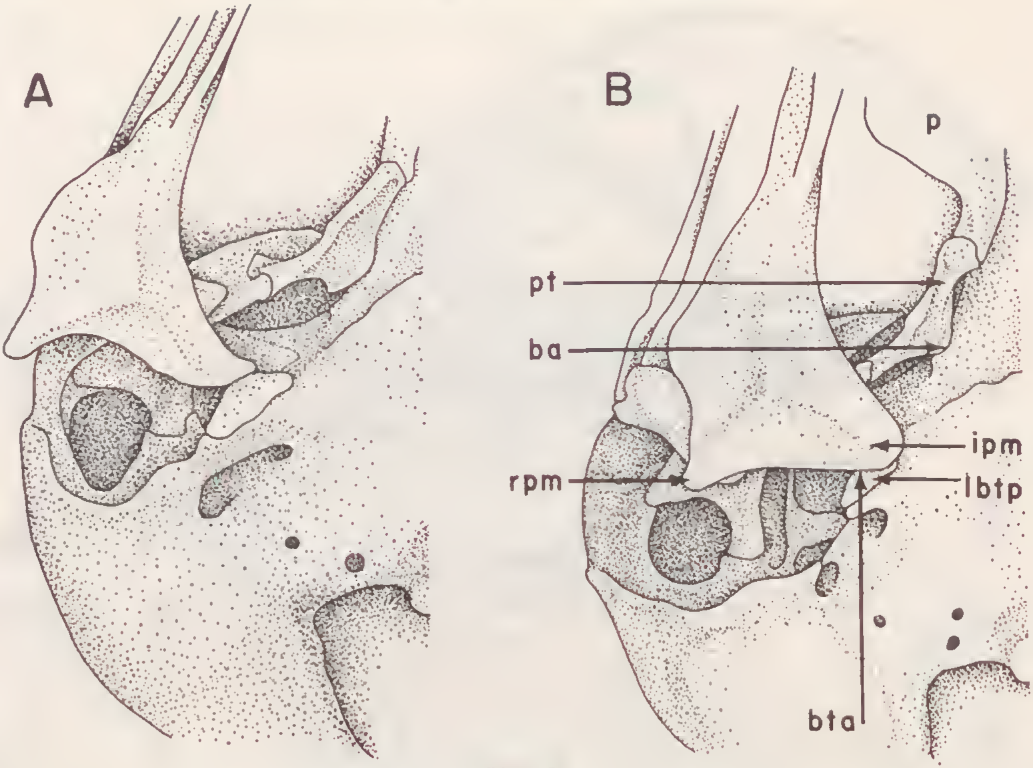

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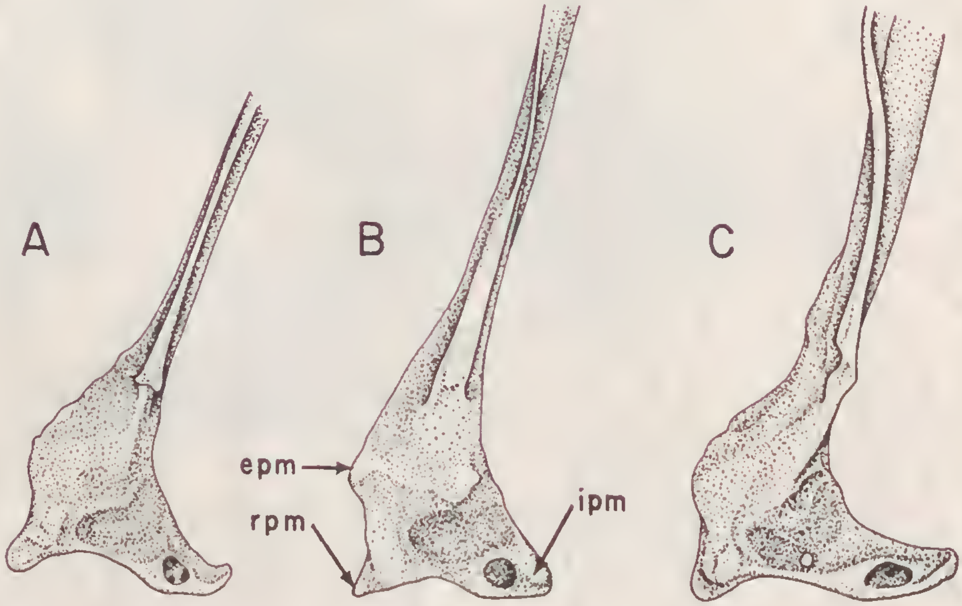

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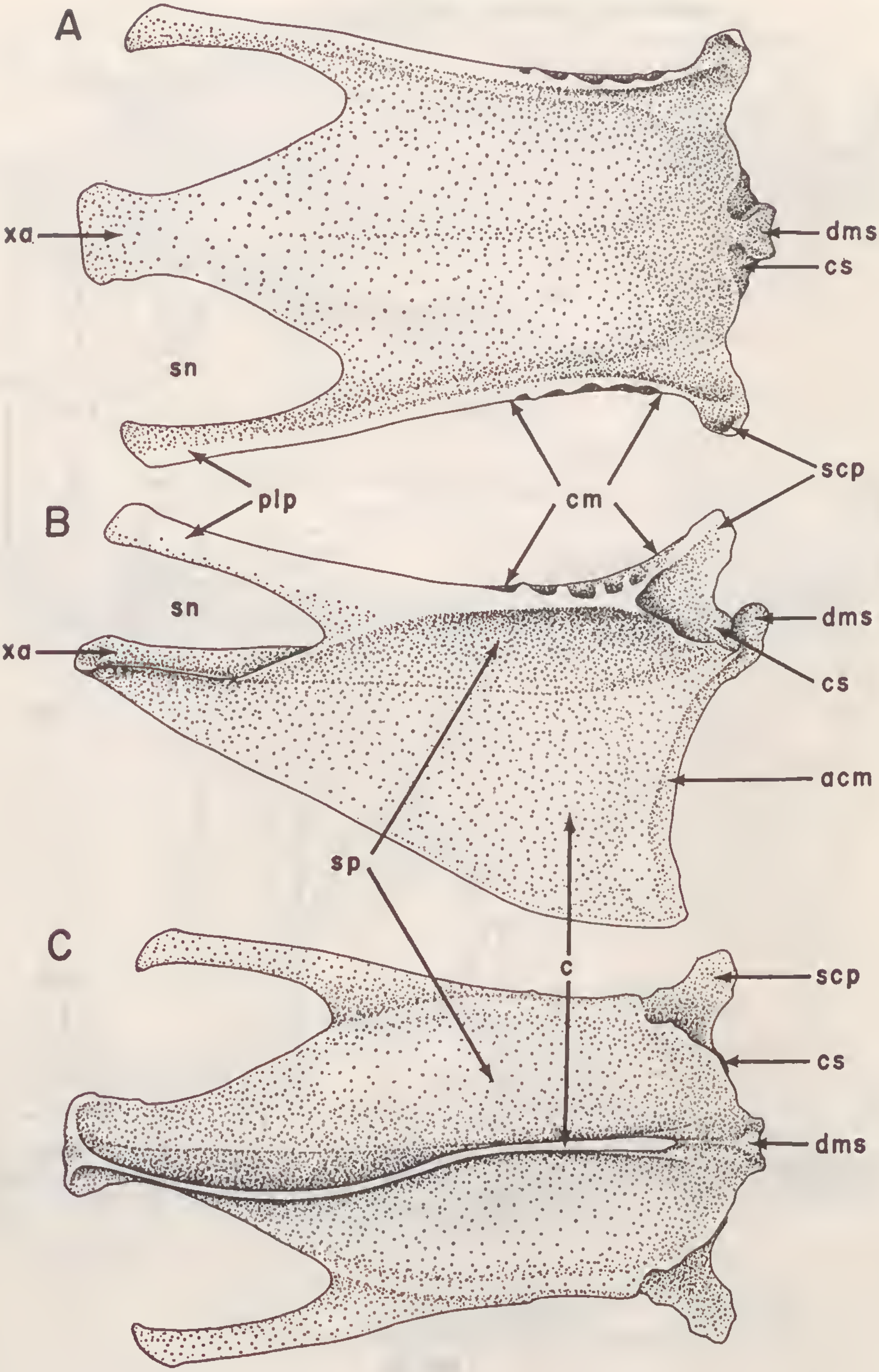

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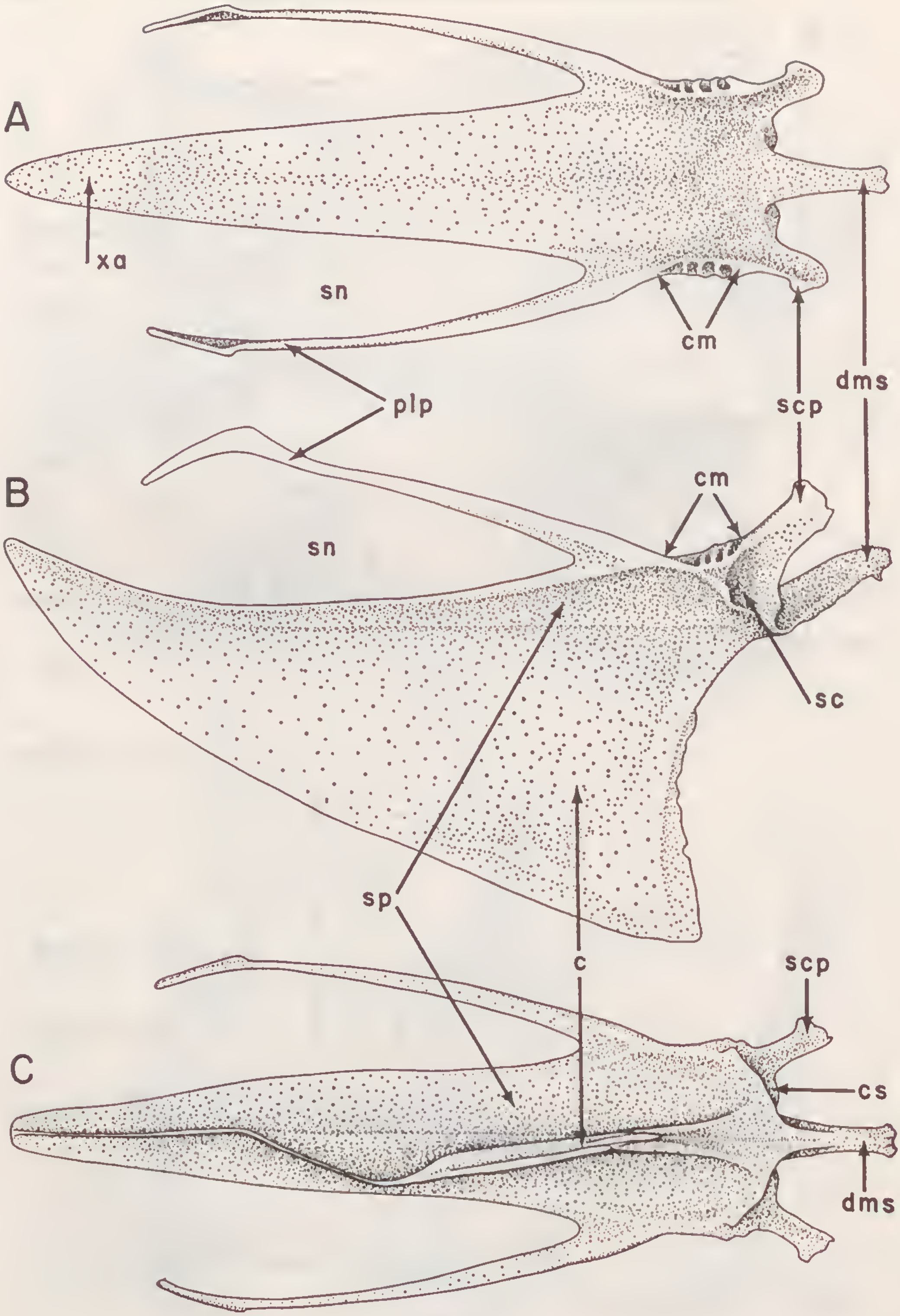

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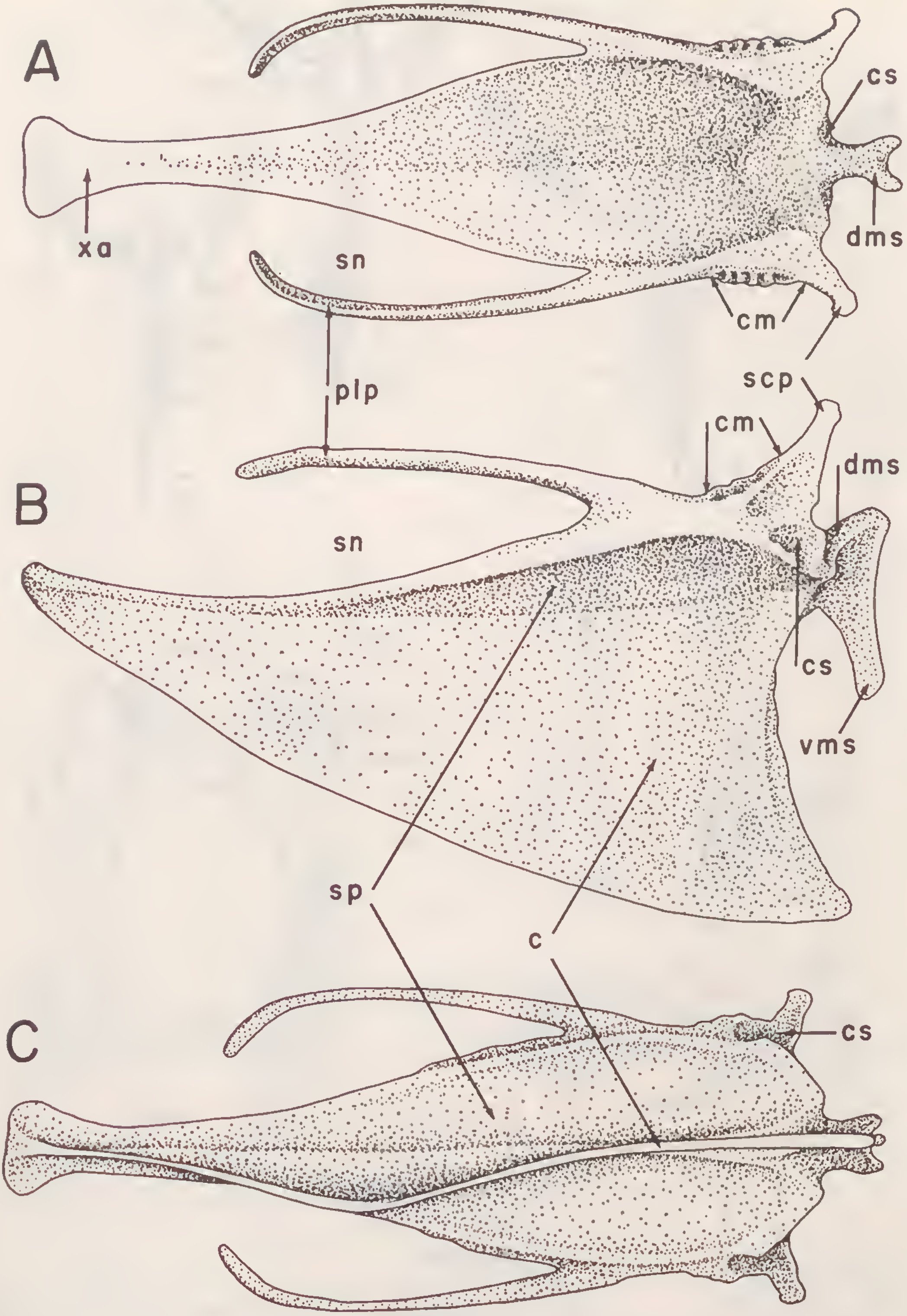

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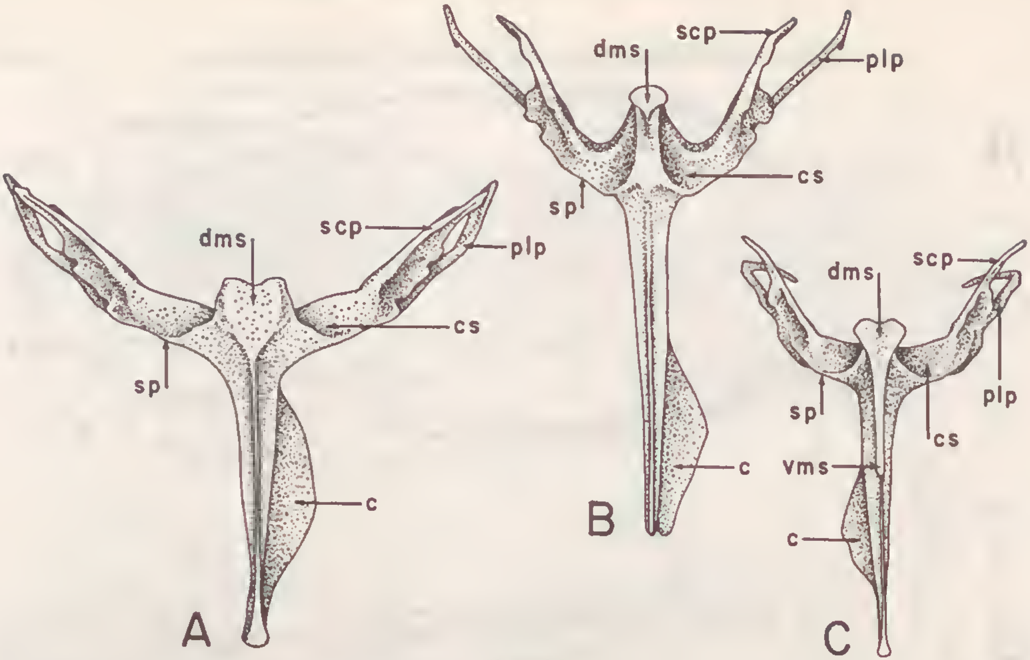
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Fig. 13

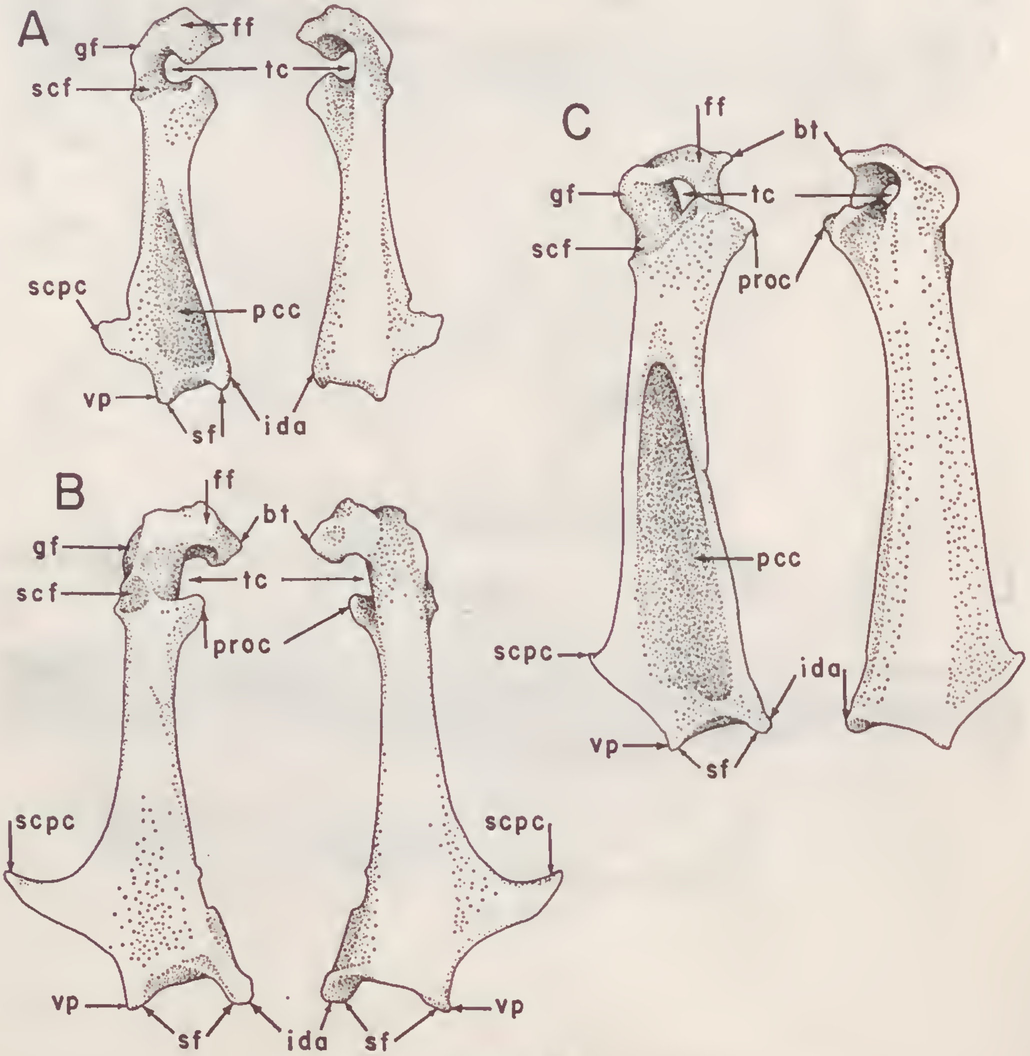
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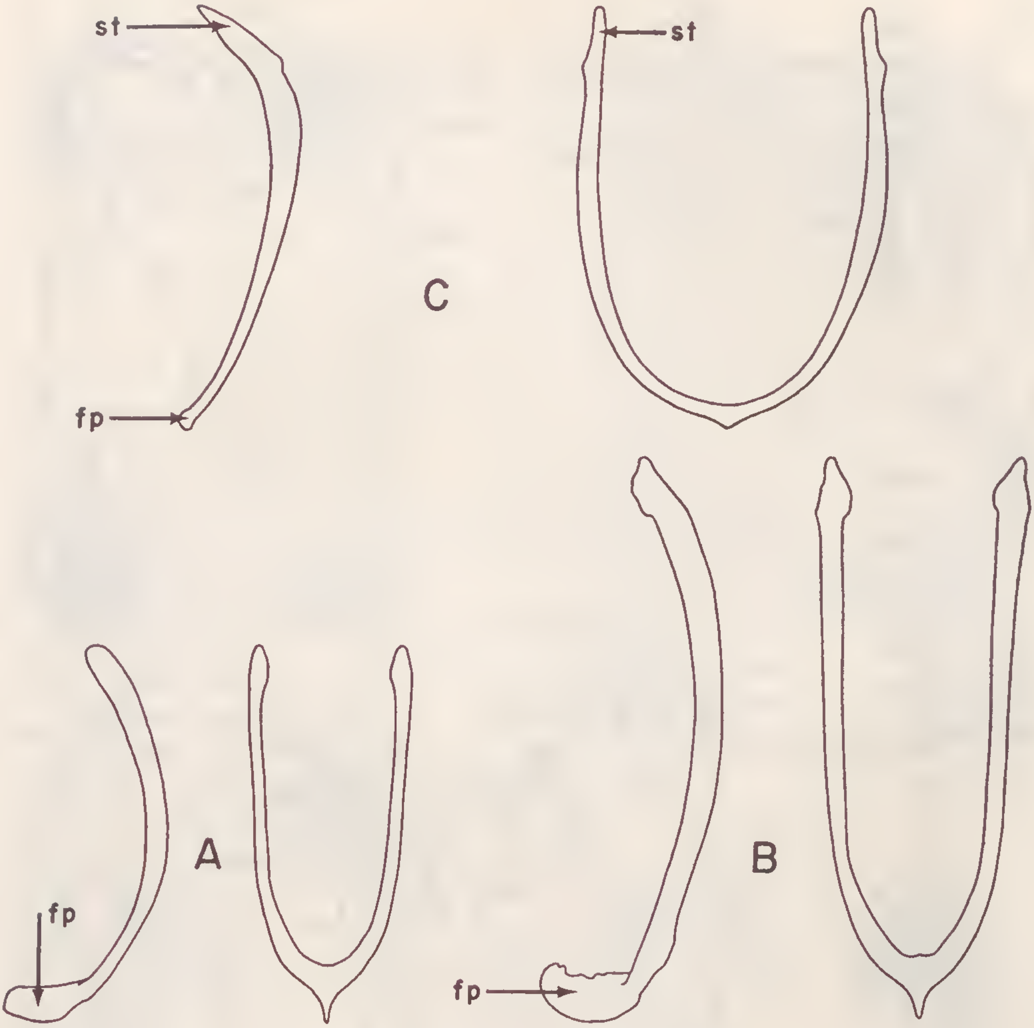
Fig. 14



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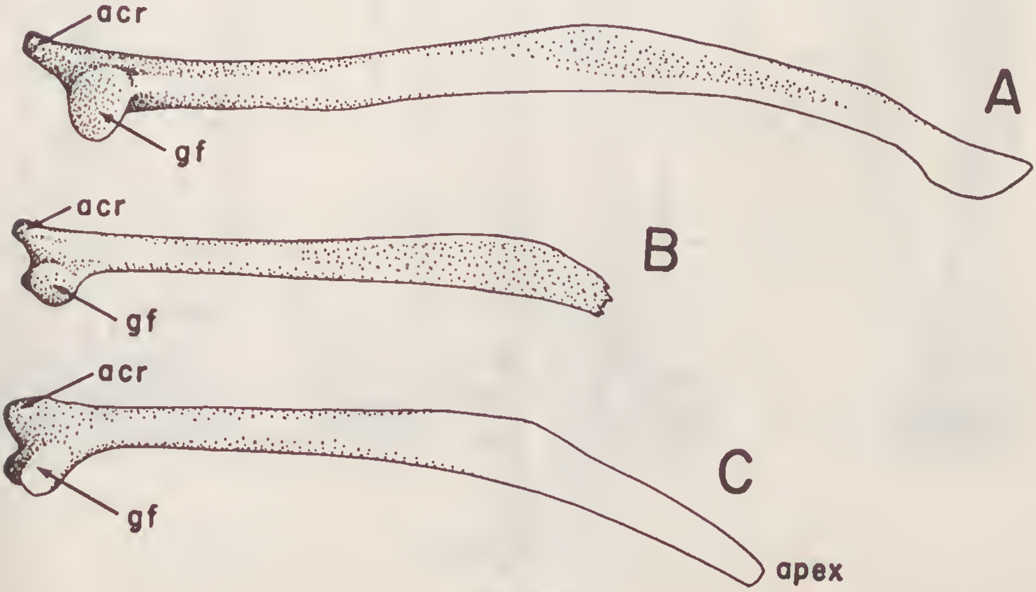

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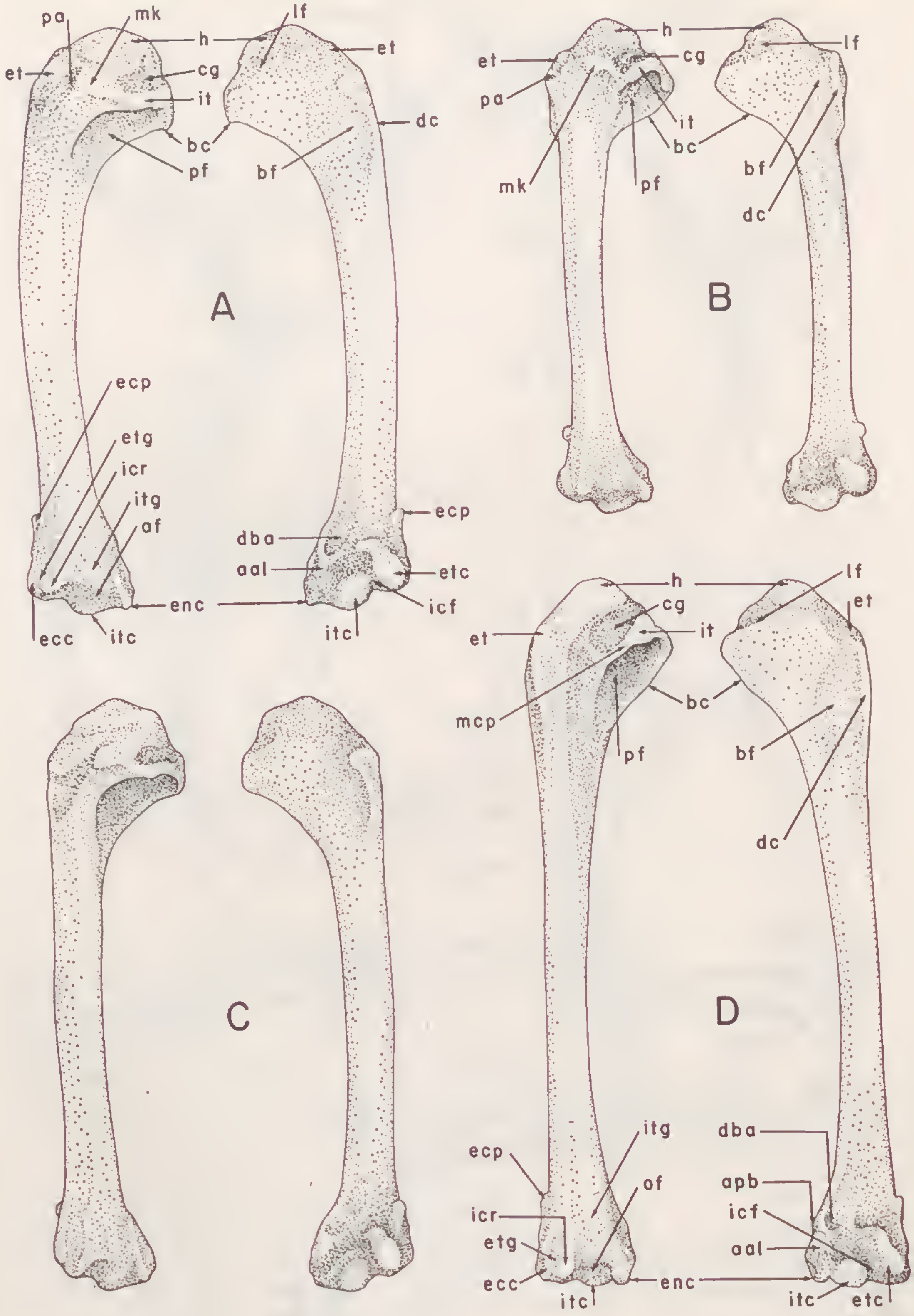
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Fig. 17

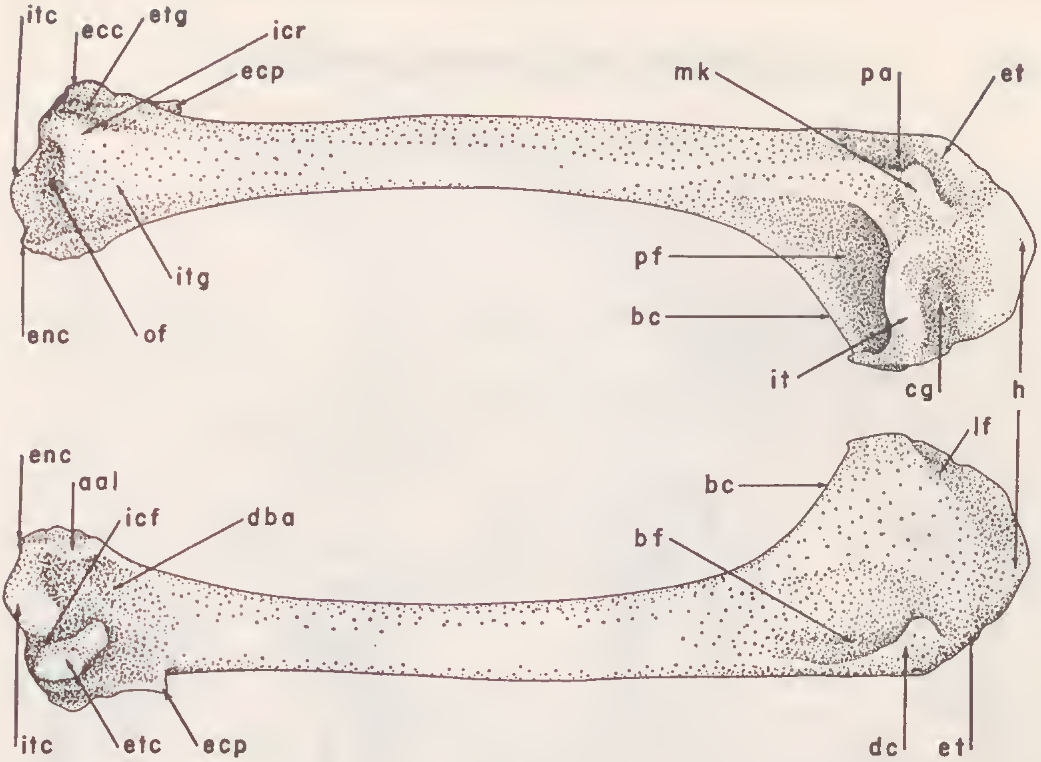
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Fig. 18

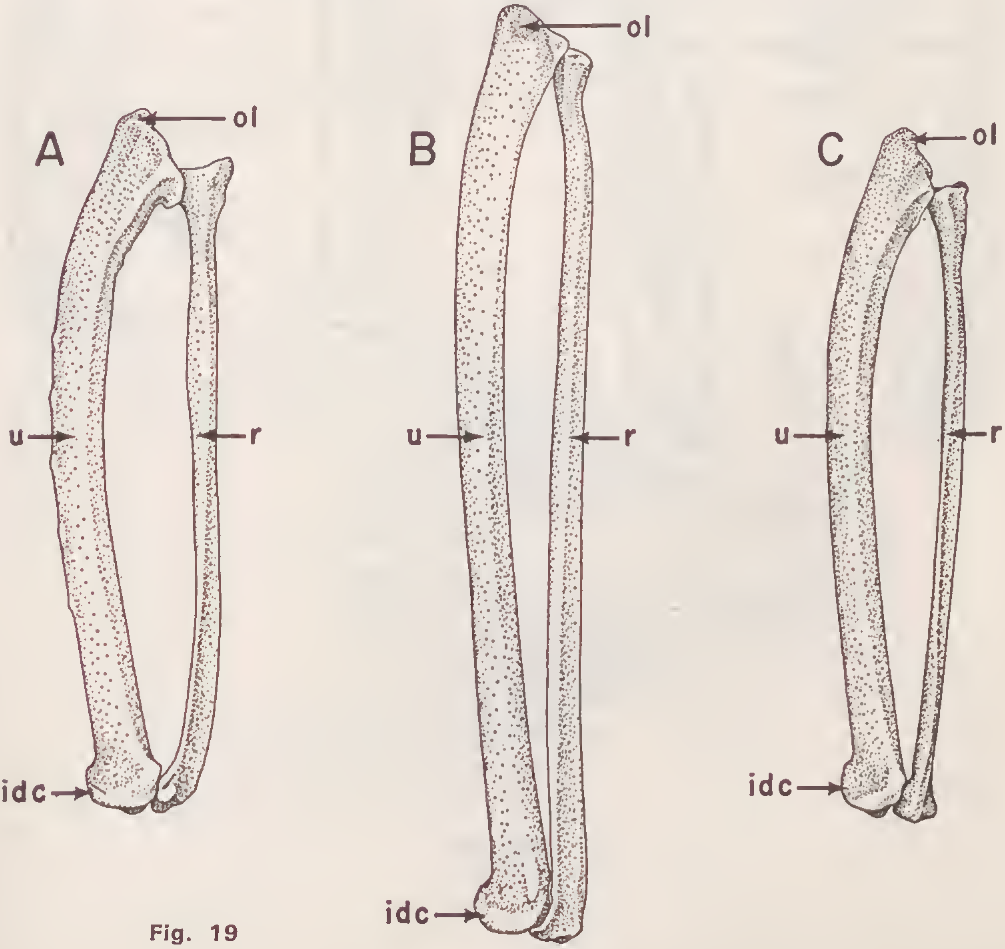
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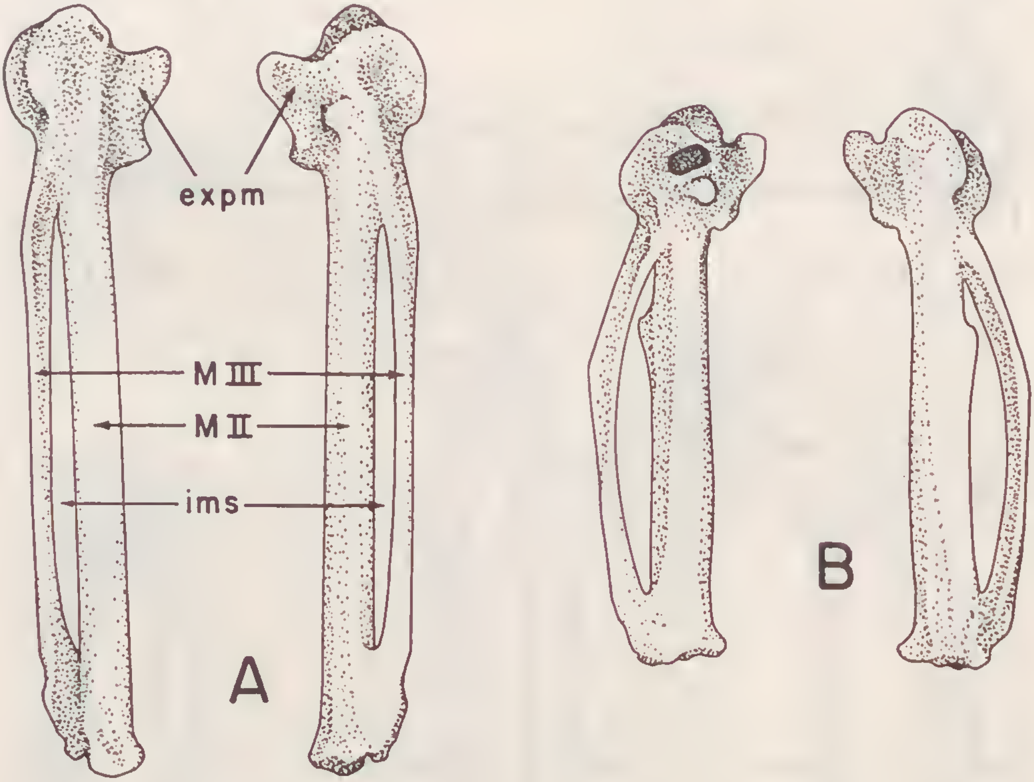
Fig. 19



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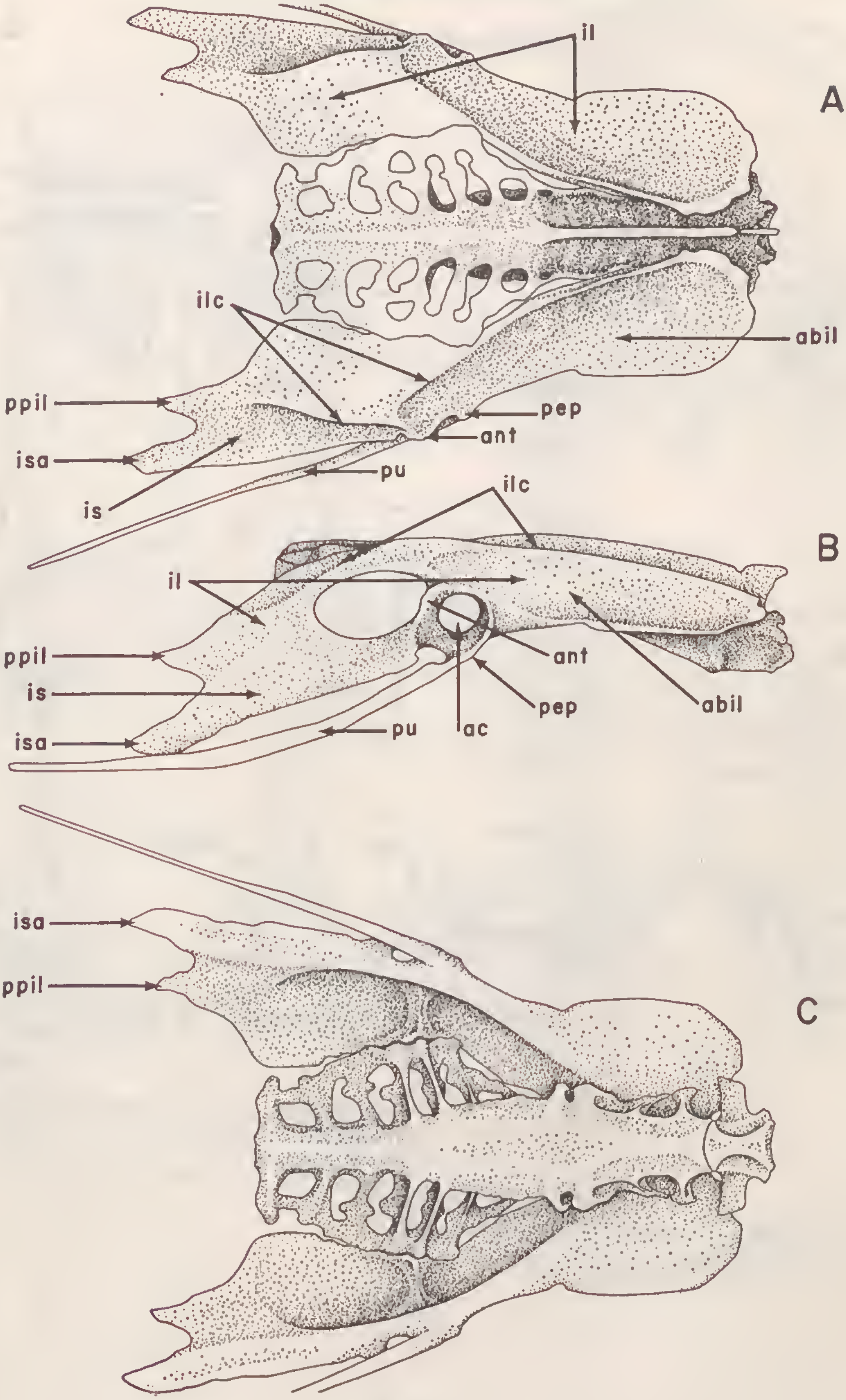
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Fig. 21

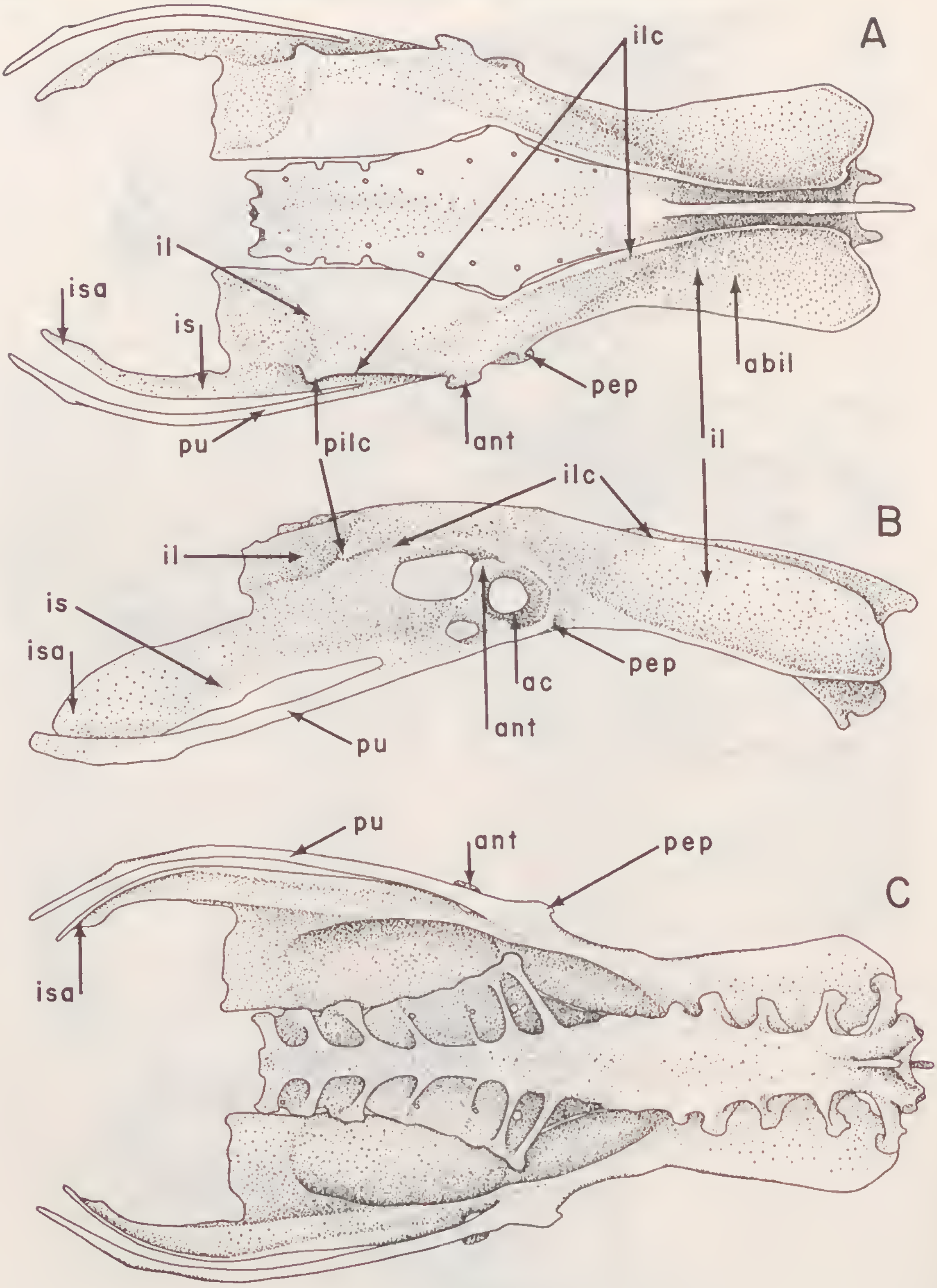
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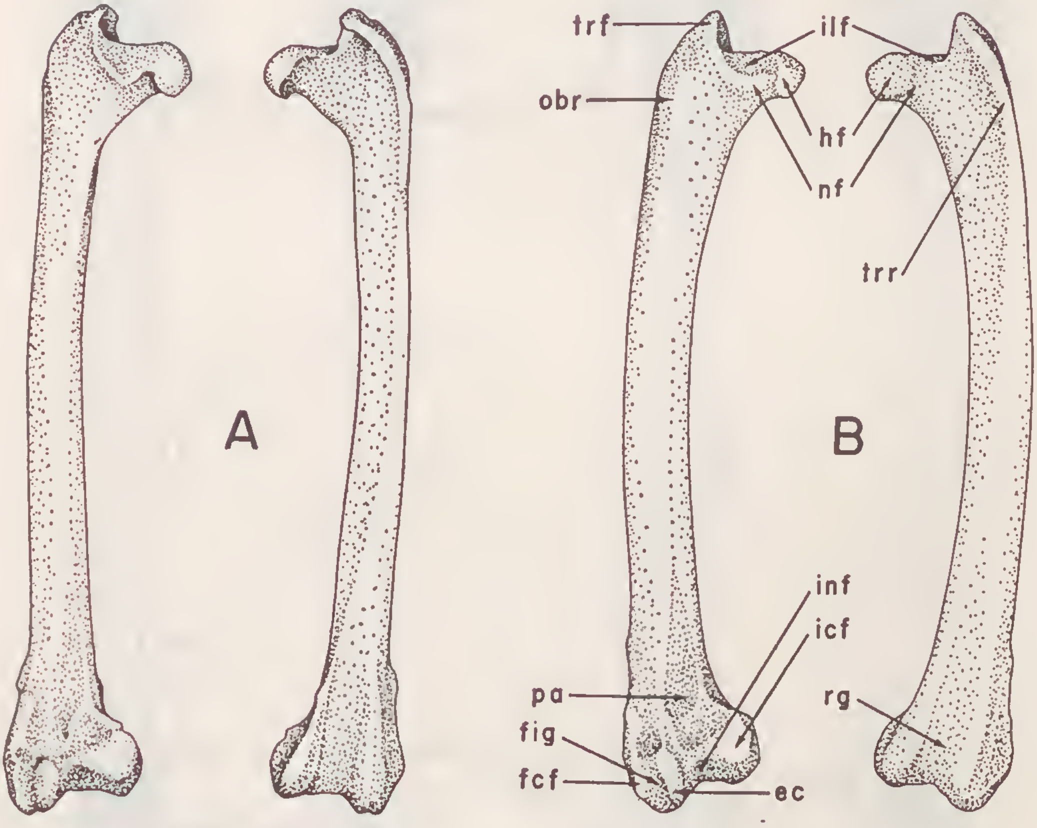
Fig. 22



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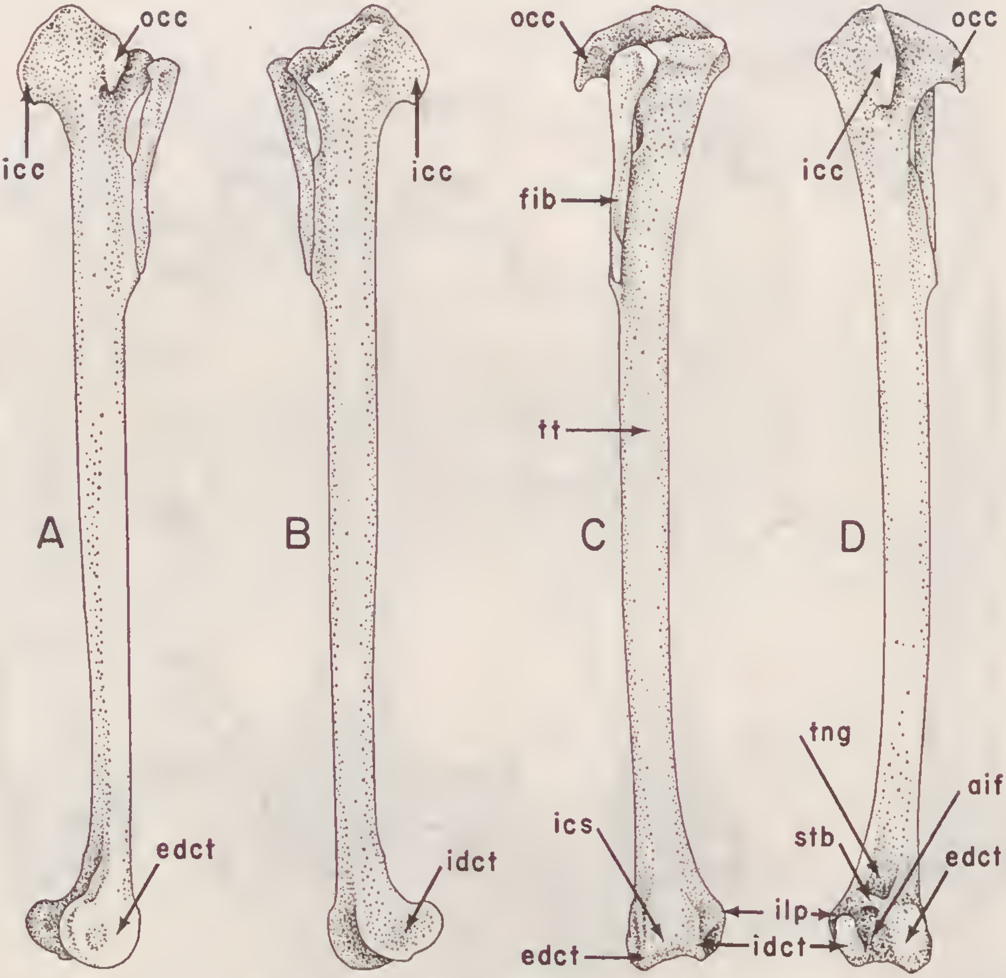
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Fig. 24

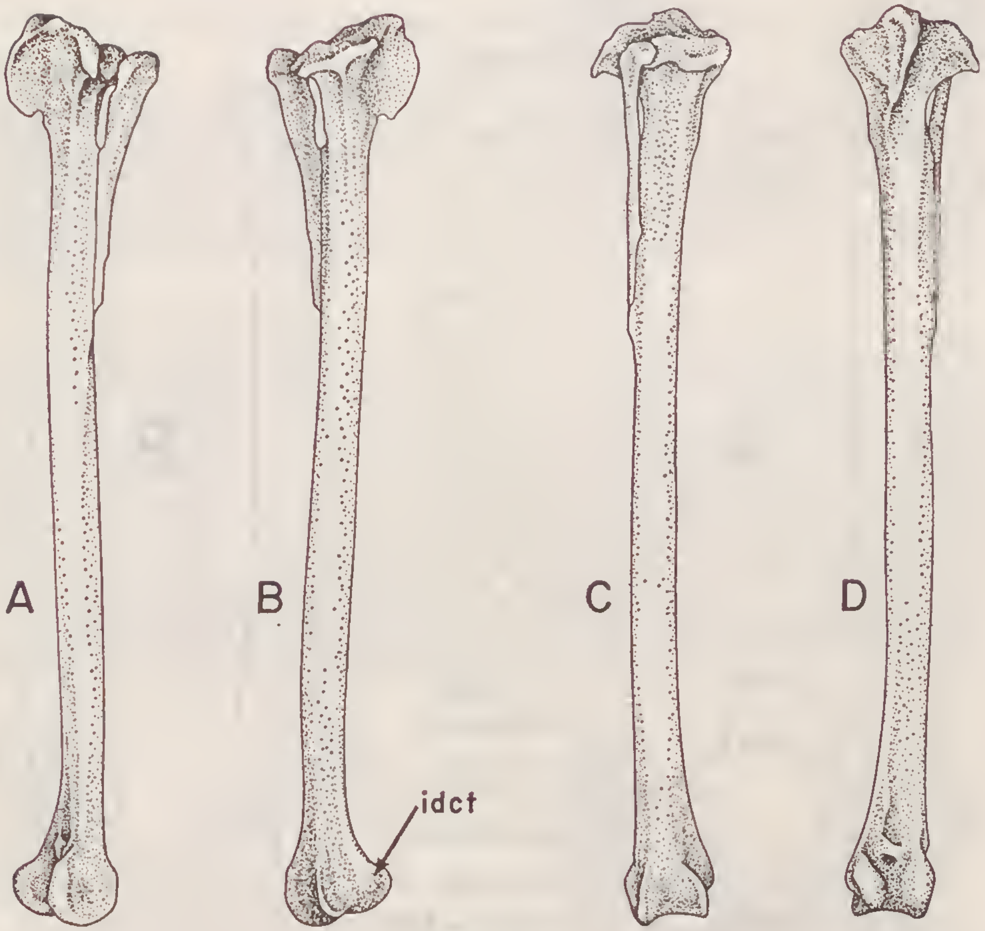

Fig. 25

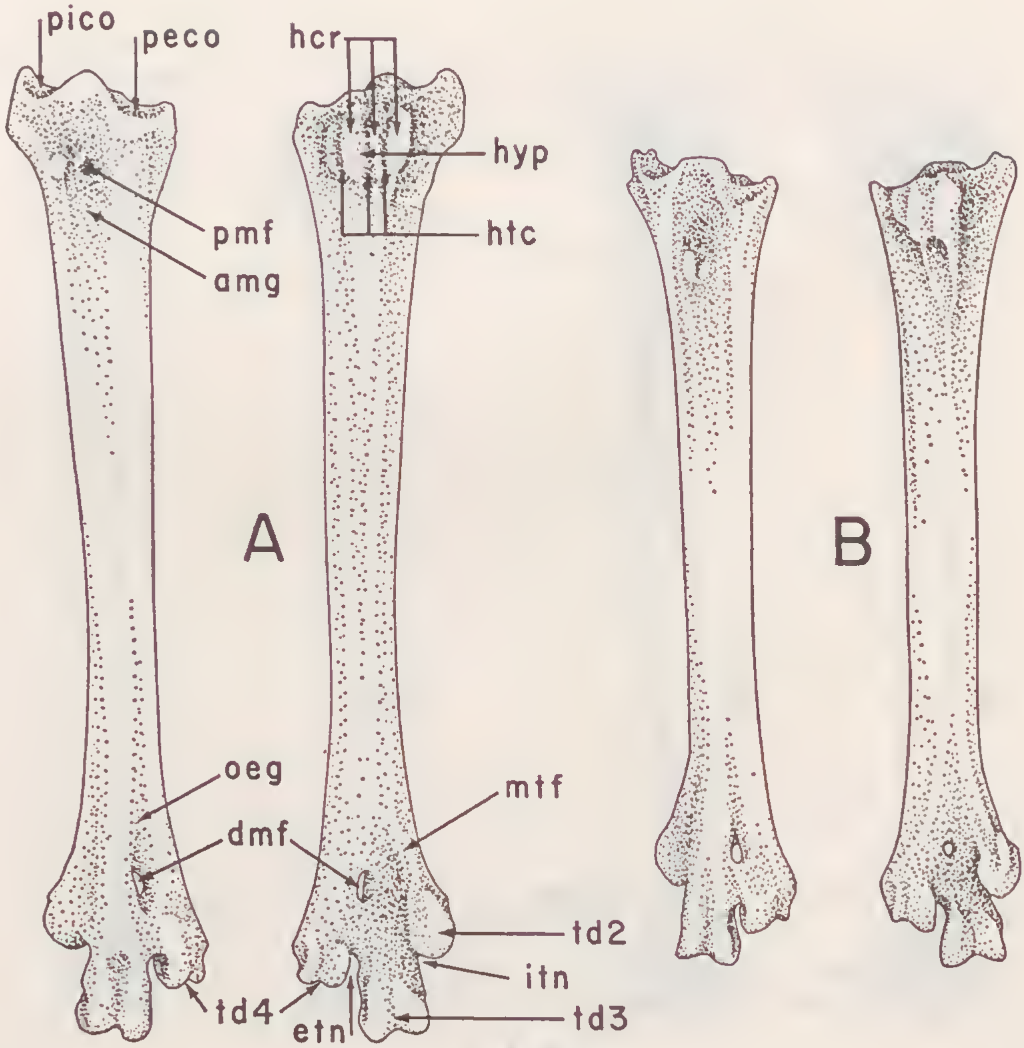

Fig. 26

15

THE TERTIARY ECHINOIDS OF SOUTH-EASTERN AUSTRALIA
IV. CAMARODONTA (2)

By G. M. PHILIP

Department of Geology, University of New England

Abstract

The following Australian Tertiary diadematacioid regular echinoids are described and figured: *Evechinus palatus* sp. nov., *Cryptechinus humilior* (Bittner) gen. nov., *Asaphechinus murrayensis* gen. et sp. nov., *A. princeps* sp. nov., *A. singletoni* sp. nov., *A. tasmanensis* sp. nov., *Grammechinus meridionalis* sp. nov., *Ortholophus lineatus* (Duncan), *O. bittneri* nom. nov., *O. morganensis* sp. nov., *O. pulchellus* (Bittner), *O. venustus* sp. nov., *O. woodsi* (Laube), *Pseudechinus* sp. cf. *P. albocinctus* (Hutton), *Paradoxechinus novus* Laube, *Tatechinus nudus* gen. et sp. nov. The sexual dimorphism of the test of *P. novus* is described and discussed.

Introduction

This paper concludes the description of the regular echinoids of the Tertiary strata of SE. Australia. Included in this part are the temnopleurids and an additional echinometrid which was discovered in the collections of the National Museum of Victoria subsequent to the writing of Part III. As in previous parts (Philip 1963, 1964, 1965b) the ages of the different strata are given in terms of local stages. Concerning these, reference should be made to Ludbrook's (1967) recent review of the correlation of the Tertiary rocks of the Australasian region. The continued assistance of individuals acknowledged in previous parts must be mentioned. Also latterly, Mr T. Darragh, Curator of Fossils in the National Museum of Victoria, has assisted in arranging the loan of material.

During the tenure of a Royal Society and Nuffield Foundation Commonwealth Bursary (1965-1966) it was possible for me to visit Vienna to restudy and photograph Laube's types in the Naturhistorisches Museum.

Systematics

Suborder ECHININA Claus
Family ECHINOMETRIDAE Gray

Genus **Evechinus** Verrill

Evechinus Verrill 1871, p. 583.
Evechinus Verrill, Mortensen 1943b, p. 297 *et seq.* (*cum synon.*); McRae 1959, p. 205.

TYPE SPECIES: *Echinus chloroticus* Valenciennes, by original designation.

DIAGNOSIS: Moderately large, thick tested echinids with trigeminate ambulacral plates, which possess a primary tubercle on every second, third or fourth superambital plate in each column. Poriferous tract broad, with pore-pairs arranged in three vertical series which may become ill-defined adapically. A vertical series of secondary tubercles occurs toward the adradial side of the poriferous tract. Poriferous tracts not widened aborally but around the peristome the ambulacra are wider than the interambulacra. Primary interambulacral tubercles large and usually with enlarged secondary tubercles forming parallel vertical series.

Distribution: *Evechinus chloroticus* (Val.), the only species of this genus so far discriminated, is the common littoral urchin inhabiting present-day New Zealand coasts. It is distributed from the Kermadec Islands in the north and to Stewart Island in the south. It also occurs in the Chatham Islands. Farquhar (1894, p. 195) records the species from 'Pliocene formations at Wanganui' and Fell (1954) states that *Evechinus* occurs in the 'lower Nukumaruan' of New Zealand.

Remarks: The occurrence of this common New Zealand echinoid genus in the Miocene/Pliocene of Australia is particularly noteworthy. It tends to indicate that the genus immigrated from Australia to New Zealand in the early Pliocene and therefore supports the conclusion that a west-to-east trans-Tasman migration of echinoderms has taken place in the late Cainozoic (Fell 1954).

Evechinus palatus sp. nov.

(Pl. 16, fig. 1-6)

Diagnosis: A species of *Evechinus* in which the subambital ambulacral triads all possess primary tubercles.

Type Specimen: Holotype and only known specimen: P23967, 'Above nodule bed, west of boat-shed, Beaumaris', Black Rock Member of Sandringham Sands, Cheltenhamian (Coll. F. A. Cudmore).

Description: The test is rounded in outline, with a flattened oral surface somewhat sunken around the peristome.

The pore-pairs lack a triserial character adapically, but this is progressively developed toward the ambitus, so that here and on the aboral surface they are regularly triserial. At and above the ambitus every second ambulacral triad lacks a primary tubercle, but beneath the ambitus primary tubercles are present on each triad. A vertical series of secondary tubercles is present on the adradial side of each poriferous tract. At the ambitus the ambulacra are 60% of the width of the interambulacra.

The interambulacra possess a regular vertical series of moderately large, smooth primary tubercles, which toward the ambitus are joined by an irregular inner and outer series of enlarged secondary tubercles. The rest of the plates are covered by closely spaced secondary tubercles and granules. The gill slits are well defined, although shallow. The perignathic girdle consists of united auricles connected by low apophyses. The apical system is unknown.

Measurements of Holotype:

h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
34·5 mm	16·0 mm	*c* 6·0 mm	10·5 mm	32(33)	17(18)

Remarks: McRae's (1959) extensive study of *Evechinus chloroticus* facilitates comparison of *E. palatus* with that species. The new species differs in that:

1. The triserial character of the ambulacral pore-pairs is only clear beneath the ambitus.
2. Each of the subambital ambulacral plate bears a primary tubercle.
3. The secondary tubercles are smaller.
4. There are fewer ambulacral plates which are therefore relatively higher. There are 32 per column in the holotype of *E. palatus*, whereas in *E. chloroticus*

Mortensen (1943b) lists between 42 and 49 in specimens of the type species of comparable size. The triserial ambulacra of *E. chloroticus* are a function of the lower ambulacral plates.

As the ambulacra of *E. palatus* are less specialized than those of *E. chloroticus* it may be directly ancestral to the living species.

Suborder TEMNOPLEURINA Mortensen

Family TEMNOPLEURIDAE A. Agassiz

1. INTRODUCTION

Present-day temnopleurids are almost exclusively confined to tropical and subtropical seas. In the Western American region the family appears to be unrepresented, but it is particularly abundant throughout Indo-Pacific waters. The group is known to extend back to the Cretaceous, but is not well represented in the fossil record except in Cainozoic rocks of the Indo-Pacific and Australasian regions. Therefore the perplexing taxonomy of fossil temnopleurids has received but scant attention.

As in other groups of regular echinoids, subdivision of the living representatives of the family depends largely on features which are lost in fossilization. Much previous work on fossil temnopleurids has been concerned with minor details of the sculpture or ornament for the purposes of taxonomic discrimination—which features are acknowledged to be exceedingly variable in adequately known living species. Thus Mortensen (1943a, p. 81) observes of *Temnopleurus toreumaticus* (Leske), 'The differences . . . in the shape of the test, the development and number of tubercles, as well as in the size of the sutural pits, are so considerable that looking at extremes one would hardly think it possible that it all could be one and the same species.' H. L. Clark (1925, p. 83) gives measurements for this species which indicate that, in mature specimens, the v.d. may vary between 47% and 73% of the h.d.

It would seem that extremely wide intraspecific variation in such features is widespread throughout the family. Sculpture, in particular, may also vary considerably with growth, for even highly sculptured juveniles may develop into obscurely, or even unsculptured adults (reported in the living genera *Pseudechinus* and *Desmechinus* and seen in many of the Australian Tertiary species).

Different palaeontologists appear to have answered the problem of variation in fossil temnopleurid species in a similar fashion, *viz.*, by naming extremes of variation in an assemblage (*i.e.*, forms taken from the same locality and horizon) as separate species. D'Archaic and Haime (1853) and Duncan and Sladen (1883) would seem to have done just this with the Indian Tertiary species (*e.g.*, *Temnechinus costatus* d'Archaic, *T. rousseaui* d'Archaic, *T. tuberculosus* d'Archaic and Haime, *T. affinis* Duncan and Sladen 1883, pp. 84-87; Pl. 13, figs. 9-17). A similar, although more exacting treatment was apportioned the Miocene temnopleurids of Java by Jeannet (*in* Jeannet and Lambert 1935). Here, from the same horizon and locality, Jeannet discriminated the following forms:

Dicoptella agassizi Lambert and Thiéry, *Dicoptella agassizi* var. *tenius* (4 specimens), *Dicoptella agassizi* var. *elevata* (4 specimens), *Dicoptella deupoldi* Jeannet (1 specimen), *Dicoptella tobleri* Jeannet (4 specimens, including one illustrated as '*D.* cf. *tobleri*'), *Dicoptella java* Jeannet (1 specimen). There can be no doubt that all of these (well described and figured) represent a single, variable species (= *Temnotrema macleyanna* (T. Woods), originally described from the Miocene of Yule Island, New Guinea by Woods 1877). It is even very likely that the subgenus

Paradicoptella, based on the species *P. rutteni*, is a further variant of this. Thus it appears that one subgenus, five species and two varieties were proposed to cover the variation in what one must suggest is but a single species.

In the Australian Tertiary species described below, an attempt has been made to characterize the extremely wide specific variation which occurs.

2. CLASSIFICATION

Mortensen (1943a) divided the family Temnopleuridae into three subfamilies, *viz.*, Temnopleurinae Duncan, Trigonocidarinae Mortensen, and Genocidarinae Mortensen.

The validity of this subdivision may be questioned, for, in the final analysis, it rests merely with the character of the pedicellariae. It seems likely that the groupings should not stand in formal classification and they certainly cannot be applied to fossil material. In dealing with fossil temnopleurids it is convenient to distinguish two groups on the basis of test morphology, *viz.*:

a. Sculptured temnopleurids
(Mortensen's (1943a) Genocidarinae + Trigonocidarinae + *Pseudechinus*)
b. Temnopleurids with pitted sutures
(Mortensen's (1943a) Temnopleurinae – *Pseudechinus*).

All of the Australian Tertiary species are sculptured temnopleurids. Elsewhere, in the Tertiary of the Indo-Pacific region, the pitted sutured temnopleurids were well represented, or were even the dominant temnopleurid group.

3. AUSTRALIAN TERTIARY TEMNOPLEURIDS

The Australian Tertiary temnopleurids are most imperfectly known. At the end of the last century two genera, six species and one variety had been proposed. Tate (1892, p. 191), however, considered there to be but two variable species, *Paradoxechinus novus* Laube and *Psammechinus woodsi* Laube, and this view has been followed by most later workers (*e.g.* H. L. Clark 1946). More recently, Fell (1949, 1964b) has described two further species, but with only passing reference to earlier work (Philip 1966).

Preliminary examination of the present collections (in which the obvious character of sculpture was emphasized to the exclusion of other features) suggested that even Tate had been too liberal. However, more searching examination of the material, in which progressively less emphasis was placed on detail of the sculpture and more on other features, such as the character of the tubercles (smooth, faintly or strongly crenulate) and the apical system, the development of gill slits, the nature of the perignathic girdle and the ambulacra, and special idiosyncrasies of some forms (the apical depression of *Paradoxechinus novus* and the bare sutures of *Tatechinus nudus* gen. et sp. nov.), led to the recognition of no less than 15 species (9 new) accommodated in seven genera, three of which are new.

Genus **Cryptechinus** gen. nov.

TYPE SPECIES: *Psammechinus* (?) *humilior* Bittner 1892, pp. 337-338; Pl. 1, fig. 3.

DIAGNOSIS: Comparatively large, sculptured temnopleurids with strongly crenulate tubercles and sharp gill slits. The pore-pairs of the ambulacra are uniserial, and the apical system is dicyclic. Strongly developed radiating sculpture on each plate may be lost during growth. The perignathic girdle consists of styliform auricles not united above the ambulacra.

REMARKS: Among the sculptured temnopleurids discussed by Mortensen (1943a), the living genus *Asterechinus* Mortensen alone possesses distinctly crenulate tubercles, and this genus in other respects is quite unlike *Cryptechinus* (the characters of *Asterechinus* are reviewed below in discussion of *Asaphechinus*). The large size, the general pattern of the sculpture which may be lost on growth, the well-developed gill slits and the non-united auricles, suggests comparison of *Cryptechinus* with the living genus *Desmechinus* H. L. Clark. In this genus, however, the pore-pairs of the ambulacra are strongly arcuate, the posterior oculars of the apical system are usually insert, and, most fundamental of all, the tubercles are smooth. *Cryptechinus* undoubtedly is most closely related to *Asaphechinus* gen. nov. described below, and perhaps this latter genus should merely be considered as a subgenus of *Cryptechinus*.

Mention should be made of the N. American Eocene species *Orthechinus pretiosus* W. B. Clark (*in* Clark and Twitchell 1915, p. 118; Pl. 56, fig. 2a-b). The illustrations of this form recently placed in the genus *Brochopleurus* by Cooke (1959) who also regarded *Gagaria americana* W. B. Clark (*op. cit.* p. 159; Pl. 73, fig. 8a-b) as its synonym. However, *Gagaria americana* was originally described as possessing perforate, crenulate tubercles, which suggests glyphocyphid rather than temnopleurid affinities for the species. Until these forms are more completely known, particularly in the character of the compounding of the ambulacra, the true affinities of the American forms cannot be decided.

The generic name, from κρυτσς, *hidden*, refers to the fact that, although the peculiarities of the type species were made known over seventy years ago, the species has been neglected as a synonym of *'Psammechinus' woodsi* Laube by Australian workers ever since.

Cryptechinus humilior (Bittner)

(Pl. 3, fig. 1-9; Pl. 4, fig. 1-6; Fig. 1a-k)

Psammechinus (?) *humilior* Bittner 1892, p. 337-338; Pl. 1, fig. 3.
Psammechinus woodsi Laube, Tate 1892, p. 191 (*partim*).
Echinopsis humilior (Bittner), Lambert and Thiéry 1910, p. 185.
Pseudechinus woodsi (Laube), H. L. Clark 1946, p. 323-324 (*partim*).
(*Non*) *Psammechinus woodsi* Laube 1869, p. 185-186, fig. 1-1b.

DIAGNOSIS: As for genus.

MATERIAL: Twenty-six specimens, fifteen of which retain their apical systems.

TYPE SPECIMEN: Although Bittner gave no locality for his species, on Tate's (*loc. cit.*) authority his two specimens came from the Murray River Cliffs. The specimen which he illustrated in Pl. 1, fig. 3 is here chosen as lectotype. The specimen is lost (I, p. 183). As neotype P17966 is selected. The specimen is from the mid-Miocene Morgan Limestone at Morgan.

DESCRIPTION: The test is comparatively large and depressed with a somewhat flattened adoral surface. The straight poriferous tracts are somewhat sunken, and adorally the test is more closely tuberculated. The peristome is wide, with small, sharp, well-buttressed gill slits. The girdle consists of high separate styliform auricles connected by low apophyses.

The apical system is small and dicyclic, with elongate oculars and with the anterior oculars more exsert than the posterior, particularly ocular 1. The madreporite is not markedly enlarged, and the raised porous area extends over most of the surface of genital 2. The genital pores are large, notably so in four specimens. Each of the genitals is ornamented by three to six secondary tubercles arranged in irregular series bordering the peristome. A single tubercle may be present toward the centre of each ocular. The plates are variably sculptured in different specimens.

The ambulacra are about half the width of the interambulacra with a narrow poriferous tract in which the pore-pairs are uniserially arranged. The primary ambulacral tubercles bordering the poriferous tract form a regular vertical series. In each echinoid triad the pore-pairs are arranged in ill-defined arcs, and usually are separated by well-defined ridges radiating from the primary tubercle. The pores themselves are small and in each pore-pair they are equal in size, with the wall between rising to a rounded elevation. The secondary tubercles are variable in number and arrangement and a bare median zone may be developed adapically.

The interambulacra possess regular vertical series of primary tubercles, similar to, but slightly larger than the corresponding ambulacral tubercles. Usually there is radiating sculpture originating from the boss of the primary tubercle, but this can be almost lost. The secondary tubercles are variable both in number and arrangement; in larger specimens, which possess poorly developed sculpture, they are more numerous and the ambital plates may bear poorly defined horizontal series of slightly enlarged secondary tubercles. The bases of the bosses of the primary tubercles are irregularly scalloped. Bare median zones in which growth ridges of the plates are seen may be developed, particularly adapically.

Measurements:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P17964	8·5 mm	4·7 mm	*c* 2·0 mm	3·3 mm	8	8
P17965	15·5	9·0	4·0	6·0	12(13)	11(12)
P17966	20·0	14·5	6·2	7·5	15	13(14)
P17967	21·0	12·5	6·0	8·0	15(16)	14(15)
P17968	24·2	13·7	7·0	10·0	18	15
P17969	26·5	16·2	7·0	9·2	18	15
AUGD17016	21·0	11·7	6·0	8·0	15	13

Abnormality: One specimen (P17965; Fig. 1a) with a broken apical system, shows one of the three genital plates present to possess two genital pores.

Synopsis of Material: From the Morgan Limestone, of Batesfordian and Balcombian age: 'Morgan', P17964-78, P18104; 'River Murray', AUGD17016; '4 miles below Morgan', P18045; 8 specimens *ex* R. J. Foster Coll., various localities in the Morgan Limestone along the Murray River Cliffs.

Remarks: Fig. 1d-f, i-l and Pl. 3, figs. 1-5, 8-9 illustrate the considerable variation in sculpture and tuberculation which is seen in this species. In general it seems that during growth the very strong radiating sculpture of small specimens is lost to varying degrees and more secondary tubercles are developed. In large specimens bare median zones which extend down to the ambitus may be developed in the ambulacra and interambulacra. Both these features are known in the living genus *Desmechinus*.

The strong radiating sculpture of small specimens compares closely with that seen in *Ortholophus pulchellus* (Bittner) which is also known only from the Morgan Limestone. In small specimens of comparable size, *Cryptechinus humilior* may be distinguished by the fewer and higher plates which possess more prominent and

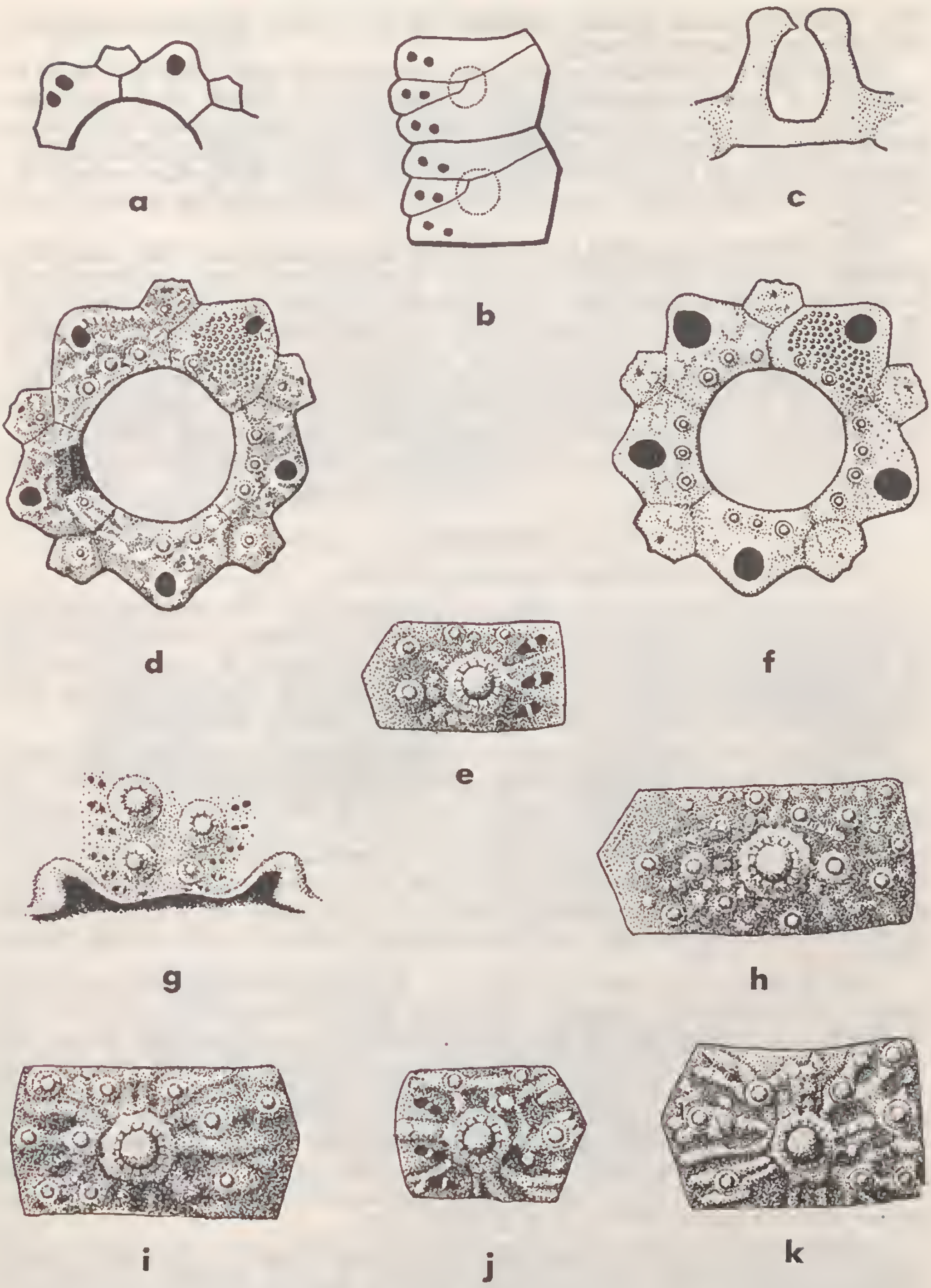

FIG. 1—*Cryptechinus humilior* (Bittner). a, Abnormal apical system with two pores in one genital plate (P17965), × 6. b, Analysis of ambital ambulacral plating (P17968), × 10. c, Auricles (P17971), × 10 approx. d, Apical system of a highly sculptured specimen (AUGD17016), × 6. e, Ambital plate of an obscurely sculptured specimen (P17968), × 10. f, Apical system of highly sculptured specimen (AUGD17016), × 6. g, Adoral termination of an ambulacral column showing the well buttressed gill slits (P17966), × 15. h, Interambulacral plate of an obscurely sculptured specimen (P17968), × 10. i, Interambulacral plate of a moderately sculptured specimen (P17966), × 10. j-k, Ambulacral and interambulacral plate of a highly sculptured specimen (AUGD17016), × 10.

more strongly crenulate primary tubercles, the more open and coarser sculpture and the fewer secondary tubercles.

The excessive enlargement of the genital pores seen in four of the specimens is suggestive of sexual dimorphism similar to that seen in species of *Prionechinus* where the females have enlarged genital pores and the males possess small pores mounted at the extremities of the plates. The dimorphism is well marked in *Prionechinus* whereas in *C. humilior* it could well arise merely from wide variation in the size of the pores—the apparent dimorphism an artefact of the present small collection.

Bittner originally described the tubercles of this species as only very doubtfully perforate. Lambert and Thiéry (*loc. cit.*), however, must have interpreted the description otherwise to list this form as a species of *Echinopsis*. The tubercles lack all trace of perforation. Although Bittner was perplexed by Duncan's (1889) definition of the genus *Psammechinus*, he had a very clear idea of the affinities of this species, for he writes 'Die Oberflächensculptur dieser Art zeigt somit gewisse Anklänge an die Gruppe der Glyphocyphinen, die ja auch sonst, insbersondere im Baue der Ambulacralplattensysteme, den Echininen äusserst nahe steht', an observation which anticipates to a remarkable degree the present-day conception of the family Temnopleuridae.

Genus **Asaphechinus** gen. nov.

Type Species: *Asaphechinus murrayensis* sp. nov.

Diagnosis: Usually large sculptured temnopleurids with strongly crenulate tubercles and sharp gill slits. The pore-pairs of the ambulacra are arranged usually in well-marked arcs within each triad. The apical system is regularly dicyclic. Mature individuals are obscurely sculptured, usually with irregular granules. The perignathic girdle consists of high auricles united above the ambulacra.

Remarks: The strongly crenulate character of the tubercles sets this genus apart from the other sculptured temnopleurids with which it could otherwise be compared (e.g. *Desmechinus*). *Asaphechinus* would seem to have closest affinity with the living genus *Asterechinus* Mortensen 1942. This genus was proposed for a single specimen from the Admiralty Islands. *Asterechinus* posseses strongly crenulate tubercles, arcuate pore-pairs in the triads, and united auricles. However, the gill slits are not sharp, the secondary tubercles are very small, the sculpture consists of peculiar radiating granules, and the margins of the bosses of the primary tubercles are closely serrate.

Thus it can be seen that the Janjukian *A. tasmanensis* sp. nov., the oldest species of *Asaphechinus*, conforms closely to the characters of *Asterechinus*, for it differs only in the absence of the peculiar radiating granules and the sharper gill slits. However, the species of *Asaphechinus* form a morphological series which show progressive specialization in the deepening of the gill slits, the enlargement of the secondary tubercles and loss of serration of the primary tubercles, and an increase in test size, culminating in the Upper Miocene species *A. singletoni*. It is thus considered unlikely that the living *Asterechinus elegans* bears any direct relationship with the Australian Tertiary forms, although conceivably both could have arisen from the same stock in early Tertiary times.

Asaphechinus is to be distinguished from *Cryptechinus* by the arcuate pore-pairs of the triads, the united auricles, and the general character of the more obscure sculpture.

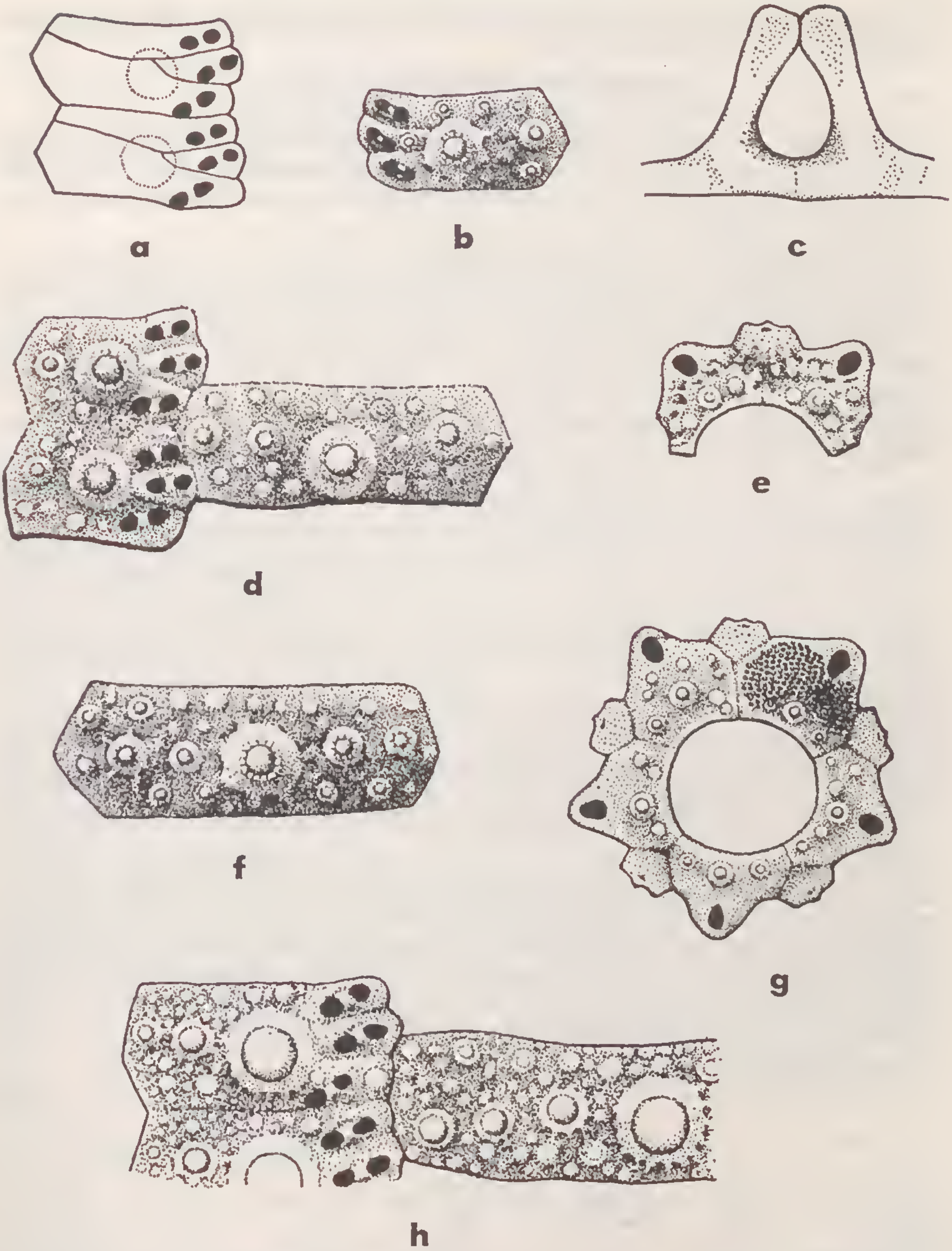

FIG. 2a-c, e-g—*Asaphechinus murrayensis* gen. et sp. nov. a, Analysis of ambulacral plates (P18173), × 10. b, Ambital ambulacral plate of holotype (P18172), × 10. c, Auricles of holotype, × 10. e, Sculptured genital plates in apical system of a small specimen (AUGD17017), × 10. f, Ambital interambulacral plate of holotype, × 10. g, Apical system of holotype, × 6. d, *Pseudechinus* sp. cf. *P. albocinctus* (Hutton). Ambital ambulacral and interambulacral plates (P18367), × 15. h, *Grammechinus meridionalis* sp. nov. Ambital ornament of holotype (P19211), × 10.

The generic name from ασαφης, *indistinct*, refers to the poorly defined sculpture of adult members of the genus.

Asaphechinus murrayensis sp. nov.

(Pl. 5, fig. 1-4, 6-7, 12; Pl. 12, fig. 5, fig. 2a-c, e-g)

Diagnosis: A moderately large species of *Asaphechinus* with incised ambulacra on the adoral surface of adult specimens. The secondary tubercles are not markedly enlarged and the bases of primary tubercles are not strongly scalloped. The apophyses are low.

Material: Eight tests, 3 with apical systems.

Type Specimen: The holotype is P18172, a test from 'lower beds, Murray River Cliffs, Swan Reach to Mannum', Mannum Formation, Longfordian.

Description: The test is low and depressed with a flattened adoral surface which is sunken around the peristome. On the adoral surface the ambulacra are incised in the larger specimens. The gill slits are small, sharp and well-buttressed. The girdle consists of strong high auricles united above the ambulacra, and connected by low apophyses.

The apical system is dicyclic but is distinctly elongate along an axis from genital 3 to ocular 1 which thus tends to be more insert than the other oculars. The madreporite is not enlarged although the raised porous area extends over most of the surface of genital 2. Each of the genitals possesses a comparatively large, centrally located secondary tubercle, and a few smaller secondary tubercles which may form an ill-defined circlet around the periproct. The oculars appear to be devoid of all ornament although a small specimen shows low irregular sculptural ridges running from the genitals to the oculars. The genital pores are rather large and slightly elongate.

The ambulacra are about half the width of the interambulacra, with narrow poriferous tracts in which the pore-pairs in each triad are distinctly, although not markedly, arcuate. The primary ambulacral tubercles are mounted close to the poriferous tracts and form regular vertical series. The secondary tuberculation is irregular but, at the ambitus, a slightly enlarged secondary tubercle may be present inside the primary tubercle.

The interambulacral plates possess rather small median primary tubercles, similar in size to the corresponding ambulacral tubercles. At the ambitus the interambulacral plates are distinctly arcuate and almost geniculate. A horizontal series of slightly enlarged secondary tubercles is present along the middle of each plate. The interambulacra are further ornamented by smaller secondary tubercles and irregular granules between which are often poorly defined pits. The bosses of the strongly crenulate primary tubercles are not markedly scalloped.

Measurements:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P18172	26·2 mm	14·0 mm	6·0 mm	9·2 mm	19	16(17)
P18173	22·5	12·2	5·5	8·5	19	16(17)
P18174	17·5	8·7	4·2	6·2	15	13(14)
AUGD17017	15·2	8·2	4·0	6·0	16	14

Synopsis of Material: Mannum Formation, Murray River Cliffs, Longfordian: 'Lower beds, Swan Reach to Mannum', P18172-4; 'Behind and west of pumping station, 4′ from top of formation' (S.A. Mines Dept. F43/55), AUGD-17017; 'Murray River Cliffs', B.M. E17731; '3 miles N. of Mannum', AUDG17021; 'Mannum, right bank', 2 specimens R. J. Foster Coll.

REMARKS: A comparatively small specimen which shows distinct sculpture, suggests that young specimens may possess well developed sculpture similar to those of *Cryptechinus humilior* (Bittner).

Asaphechinus princeps sp. nov.

(Pl. 5, fig. 8-10; Pl. 12, fig. 5; Pl. 14, fig. 1-3; Fig. 3c, e, g)

DIAGNOSIS: A large thick-tested species of *Asaphechinus* in which the ambulacra of the flattened adoral surface are not incised nor is the test sunken around the peristome. The subambital secondary tubercles are enlarged to be of similar size to the small primary tubercles, so that horizontal series of tubercles are present beneath the ambitus.

MATERIAL: Four tests, one with apical system.

TYPE SPECIMEN: The holotype is AUGD17020, a large test lacking the apical system from '3 miles N. of Mannum, right bank of Murray River', Mannum Formation, Longfordian.

DESCRIPTION: The test is large with a flattened adoral surface which is not sunken around the peristome. The peristome is distinctly notched, with sharp gill slits. The auricles are broken in the available material, but the girdle appears to have been similar to that of *A. murrayensis*.

The apical system is dicyclic, but is poorly preserved in the available specimen. The madreporite is not enlarged and the genital plates appear to have been ornamented with secondary tubercles which form a circlet around the peristome.

The ambulacra are about half the width of the interambulacra and possess wide poriferous tracts in which the pore-pairs are strongly arcuate in each low triad. In each pore-pair the wall between the pores rises to a rounded elevation and the inner pore is larger and more rounded than the outer pore. The primary ambulacral tubercles, which form a regular vertical series, are mounted close to the poriferous tracts leaving a wide median zone in the ambulacra.

The interambulacral plates possess small, centrally placed primary tubercles. Above the ambitus the secondary tubercles are small and irregularly spaced, but at and below the ambitus some of the secondary tubercles are enlarged, and immediately below the ambitus these attain a size similar to the small primary tubercles, so that horizontal series are formed on each plate. The tubercles are strongly crenulate, and the bases of the bosses are markedly scalloped. Apart from the tubercles the surface of the test is marked by irregular granules and low ridges, which impart a peculiar vermiculate appearance to the surface of the test (Pl. 5, fig. 10) particularly adapically. In the interambulacral midzone are distinct growth ridges.

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
AUGD17021	31·0 mm	17·5 mm	9·0 mm	*c* 11·0 mm	24	16(17)
AUGD17018	35·0	*c* 19·00	—	12·0	—	—
AUGD17020	44·5	28·5	9·5	12·5	29(30)	20

Synopsis of Material: Mannum Formation, Murray River Cliffs, Longfordian: 'Sec. 519, Finnis' (*ex* S.A. Mines Dept. F46/55) AUGD17018; '3 miles N. of Mannum, right bank', AUGD17020-1, and 1 further specimen, R. J. Foster Coll.

Remarks: *Asaphechinus princeps* occurs with *A. murrayensis* in the Mannum Formation. Apart from its larger size, the features by which *A. princeps* may be distinguished are:

1. The lower ambulacral plates.
2. The absence of incised ambulacra on the adoral surface.
3. The peristomial margins are not sunken.
4. The enlargement of the inner pores of each pore-pair.
5. The bases of the bosses of the primary tubercles are strongly scalloped.
6. The relatively smaller primary tubercles and the more sparse secondary tuberculation, particularly of the adipical surface.
7. The enlargement of the subambital secondary interambulacral tubercles.

Features 3 and 4 are not seen in other species of *Asaphechinus*.

A striking character of three of the specimens is the peculiar vermiculate appearance of the surface of the test (Pl. 5, fig. 10; Pl. 14, fig. 2). This, however, appears to be variable, for in the fourth specimen referred to the species (Pl. 12, fig. 5) this ornament is not well developed although the surface detail of this test is, for the most part, obscured.

Asaphechinus singletoni sp. nov.

(Pl. 6, fig. 1-4, 8-12; Pl. 12, fig. 3-4, 7; Pl. 13, fig. 4; Fig. 3a-b, d, f, h-i)

Diagnosis: A large species of *Asaphechinus* with very large secondary interambulacral tubercles on the adoral surface. The apophyses extend as extremely high ridges between the spatulate auricles.

Material: Ten tests, one with apical system.

Type Specimen: The holotype is a large test from the Singleton Collection (593) and is now catalogued as MUGD3490. It is from Beaumaris from the Sandringham Sands of Cheltenhamian age.

Description: The test is large and usually depressed with a rounded outline, and a flattened adoral surface which is slightly concave around the relatively small, sharply notched peristome. The auricles are high and spatulate, and are united above the ambulacra. The apophyses, the peristomial faces of which are furrowed by continuations of the gill slits, form high walls between the auricles.

The apical system is regularly dicyclic with the madreporite not enlarged although the raised porous area extends over most of the surface of genital 2. Each of the genitals possesses a comparatively large, centrally located secondary tubercle, bordered on each side by a further secondary tubercle so that a circlet is formed around the periproct. Each of the ocular plates bears a similar secondary tubercle. All plates bear irregular sculptural ridges. The genital pores are comparatively large and rounded.

The ambulacra are slightly wider than half the width of the interambulacra. The poriferous tracts are comparatively wide as the pore-pairs are distinctly arcuate in each echinoid triad. The primary tubercle of each plate is well separated from the poriferous tract, usually with a small secondary tubercle mounted between it and the median pore-pair of each triad. The pore-pairs in each triad are separated

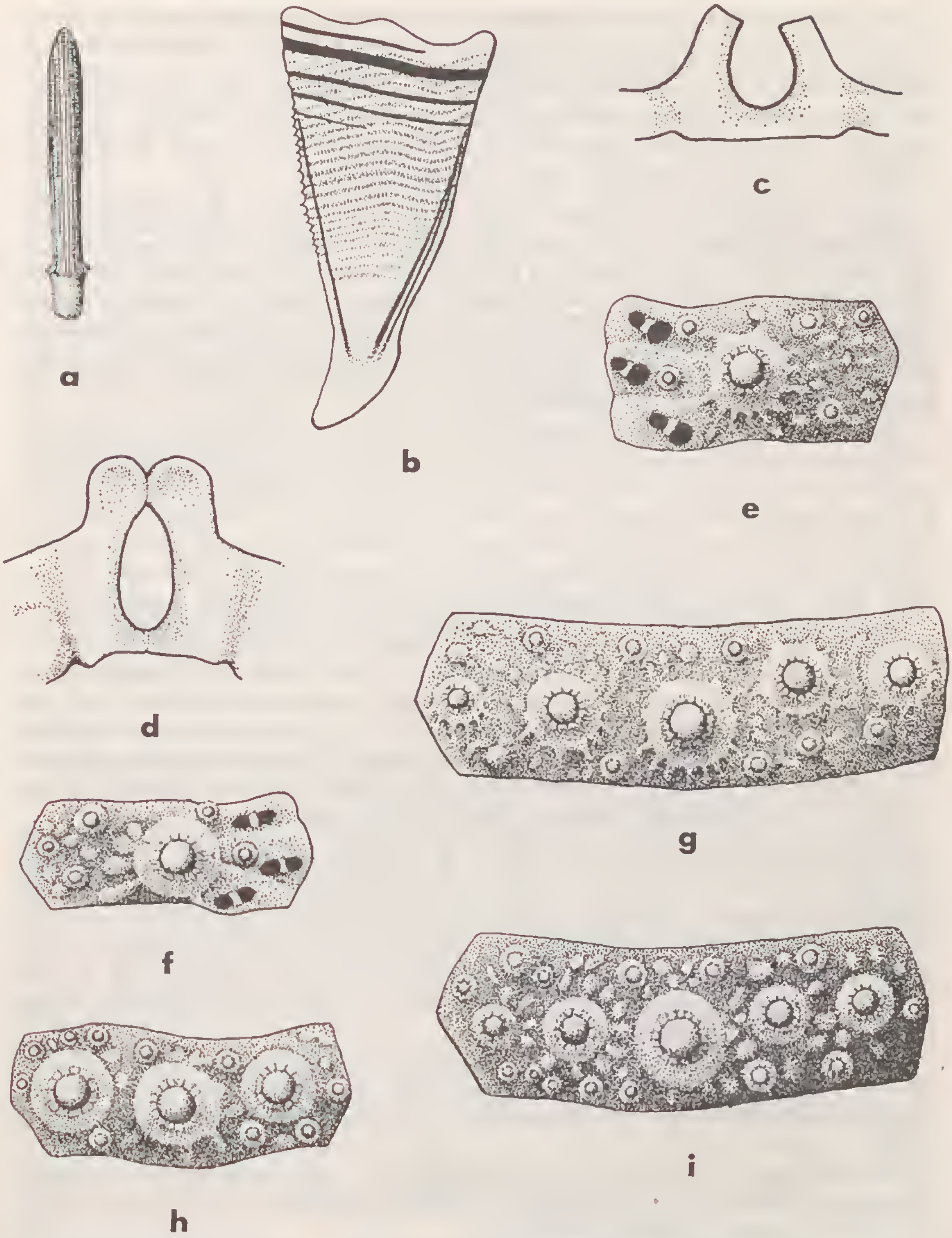

Fig. 3a-b, d, f, h-i—*Asaphechinus singletoni* sp. nov. a, Radiole (MUGD34901), × 10. b, Interpyramidal face of right maxilla, showing growth zones oblique to the sinuous ridges for the attachment of the comminator muscles (MUGD3490B), × 8 approx. d, Auricles (MUGD3490), × 10. f, Ambital ambulacral plate of holotype (MUGD-3490), × 10. h, Subambital interambulacral plate of holotype, × 10. Ambital interambulacral plate of holotype, × 10. c, e, g, *Asaphechinus princeps* sp. nov. c, Broken auricles of holotype (AUGD17018), × 6. e, Ambital ambulacral plate of holotype, × 12 approx. g, Ambital interambulacral plate of holotype, × 12 approx.

by low ridges radiating from the bosses of the primary tubercles. The pores themselves are rounded, with the wall between rising to a distinct elevation which is truncated below by a shallow groove. The secondary tubercles are irregularly arranged, with only one or two on the most adapical plates, while at and immediately below the ambitus an enlarged secondary tubercle is present on each plate inside the primary tubercle. Because the ambulacral plates are low, the primary tubercles are closely spaced in a regular vertical series.

The interambulacral columns possess regular vertical series of crenulate primary tubercles, similar to but slightly larger than those of the corresponding ambulacral plates. Adapically the interambulacral plates are covered with small secondary tubercles. At the ambitus on each plate two of these are slightly enlarged, while immediately below the ambitus they become similar in size to the primary tubercles. Between the secondary tubercles the plates are ornamented by often elongated, somewhat radiating granules, and the base of the bosses of the larger tubercles may be irregularly scalloped. The surface of immature specimens is marked by faint, irregular sculptural depressions (Pl. 13, fig. 4).

LANTERN, ETC: During its cleaning the holotype was inadvertently fractured, so the soft matrix within the specimen was completely removed. Parts of the lantern and several radioles were discovered, lodged behind the girdle. Recovered from the matrix within the specimen were (MUGD3490 A-I): 2 maxillae, 2 teeth, 1 rotula (brace), 4 small radioles. Subsequently a further collection of lantern remains removed from P23971 was discovered in the National Museum, Melbourne collections. These include: 5 maxillae, 1 rotula, 3 teeth, 6 epiphyses and 1 compass.

The lantern remains are typically camarodont. The upper surfaces of the maxillae in the second collection are well preserved and show their pitting.

Of interest is the fact that the maxillae show 'growth lines' on the intermaxillial faces. Growth zones are normally seen in all the echinoderm remains from the Mordialloc Beds at Cheltenham; the limonite of the highly ferruginous sediments appears to have permeated the calcite, deeply staining sutures, and often differentially staining different growth zones within the ossicles. In some specimens there has also been differential solution of these growth zones.

For obvious reasons there is no information available concerning the growth of maxillae, but, from general considerations, it would seem likely that the pyramids would grow mainly at their upper ends. This proves to be the case. The later growth increments, at least in the plane of the interpyramidal faces, are mainly transverse with only slight vertical component. The increments cut the low, sinuous ridges which afforded the attachment of the comminator muscles. Together with a great increase in the height of the pyramid there has been only a slight increase in the width of the lower region of the maxilla.

The radioles are all small with a wide base and a prominent milled ring. The somewhat fusiform shaft tapers to a distal point. The acetabulum is poorly preserved on the only specimen which shows the base, so that the crenulation is not visible.

SYNOPSIS OF MATERIAL: From the Sandringham Sands at Beaumaris, Cheltenhamian: MUGD3490, BME17858-9, P23971, P23989; 'Above nodule bed', P23968-9; 'Loose in shingle', P23982-3.

REMARKS: Many of the tubercles of the type specimen have been stripped of their crenulation. Weathering of the specimen, in other respects well preserved,

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs
P23968	14·5 mm	8·0 mm	*c* 4·5 mm	5·5 mm	15(16)	13(14)
P23969	18·0	9·5	4·0	6·0	15(16)	14
P23982	19·0	9·5	—	7·5	17	15
BME17895	24·0	11·5	*c* 6·0	9·5	18	14(15)
MUGD3490	32·0	16·2	6·0	10·0	23(24)	17(18)
P23971	34·0	24·0	7·0	11·0	29(30)	21(22)

appears to have been initiated around the parapet of the tubercles and in some cases has continued until now most of the boss has been removed, leaving the mamelon on a 'stalk' of the calcite of the central part of the boss. This would seem to indicate that the glossy mamelons are composed of calcite harder than that of the bosses. Other tubercles possess the strong crenulation typical of *Asaphechinus*.

The broad subambital pit in one of the interambulacral areas of the holotype is apparently the work of some boring organism. However there is no evidence to suggest that this is not *post mortem*.

Asaphechinus tasmanensis sp. nov.

(Pl. 6, fig. 5-7; Pl. 15, fig. 2; Fig. 8g-h, j)

DIAGNOSIS: A small species of *Asaphechinus* with shallow gill slits, small primary tubercles and a flattened adoral surface.

MATERIAL: Five tests.

TYPE SPECIMEN: Holotype, P19043, 'Upper bed, Table Cape', i.e. Fossil Bluff Sandstone of Janjukian age.

DESCRIPTION: The test is small and depressed with a flattened adoral surface. The gill slits are small and relatively shallow.

The apical system is distinctly elongate with ocular I more insert than the other oculars. The pores of the madreporite extend over almost all of the surface of genital 2. The genitals are ornamented by three or four secondary tubercles, the central one of which is usually slightly enlarged. The genital pores are rather large and tear-shaped and mounted distally. The short oculars may be obscurely ornamented by occasional granules, as may also be the genitals.

The ambulacra are about half the width of the interambulacra with a comparatively narrow poriferous tract although the pore-pairs of each triad are arcuate. The primary ambulacral tubercles form a regular vertical series, and one or two secondary tubercles and obscure granules are present on each plate.

The interambulacral plates possess rather small, centrally mounted primary tubercles, which form regular vertical series. The small, irregularly placed secondary tubercles form ill-defined horizontal series on the plates toward the ambitus. The obscure sculpture is of irregular ridges, granules and pits, making the surface of the test rough. The primary tubercles are strongly crenulate, and the bases of the bosses are scalloped.

SYNOPSIS OF MATERIAL: The holotype and P19042, P23984-6, all from the type locality.

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P23985	20·5 mm	8·0 mm	*c* 5·0 mm	7·5 mm	16	13(14)
P19042	17·8	8·0	5·0	6·0	15	12(13)
P23986	16·5	7·5	4·5	6·5	14(15)	13
P19043	14·0	8·0	4·5	6·0	13(14)	11

REMARKS: The girdle was broken in the specimen it was possible to excavate; however, it appears to have been the same as that of *A. murrayensis*. Indeed, this form is very similar to the small specimens of *A. murrayensis*, and perhaps should be regarded as only a subspecies.

Genus **Grammechinus** Duncan and Sladen

Grammechinus Duncan and Sladen 1885, p. 82.
Grammechinus Duncan and Sladen, Mortensen 1943a, p. 374, (*cum synon.*)
? *Goniosigma* Fell 1964, p. 201.

TYPE SPECIES: *Grammechinus regularis* Duncan and Sladen, by monotypy.

DIAGNOSIS: Comparatively large forms with a somewhat fragile test, flattened on the adoral surface and slightly sunken around the peristome. The tubercles are smooth, and enlarged secondary tubercles form horizontal series in both the ambulacra and interambulacra. The gill slits are distinct and well buttressed. The pore-pairs are arranged in distinct arcs of three.

REMARKS: This genus was proposed by Duncan and Sladen for the adoral portion of a single specimen from the Miocene of Kattywar. Mortensen (*loc. cit.*) considered from the published information that it was impossible to decide whether or not the form represented a temnopleurid. However, as illustrated, the temnopleurid affinities of *Grammechinus* are indicated by the depressions in the horizontal sutures, which are bridged by ill-defined ridges running between the primary tubercles, and also the obscurely radiating granules. The genus thus can be regarded as belonging to the sculptured temnopleurids. The Australian species described below lacks the depressed horizontal sutures of the type species, but its affinities are indicated by the scalloped bosses of the tubercles, and also the presence of obscure pits on the surfaces of the plates. In other respects it would seem to be identical with the Indian species.

There can be little doubt that *Grammechinus* is closely related to, if not identical with, the living genus *Desmechinus* H. L. Clark, but until further information is available, particularly concerning the apical system and auricles of *Grammechinus*, the safest procedure is to leave the genera separate. This may also be said of the genus *Javanechinus* Jeannet, from the Miocene of Java, which was placed in synonymy with *Desmechinus* by Mortensen merely on the basis of the surface ornament (Mortensen *op. cit.*, p. 339). Although Jeannet describes the peristome as notched, the gill slits of *Javanechinus* seem to be far less distinct than those of *Desmechinus* and *Grammechinus* (Jeannet and Lambert 1935). Thus, although the value of these various genera is questionable, from the information which is at present available they cannot be merged safely.

The same must be said of *Goniosigma* Fell 1964, based on *Echinus enysi* Hutton 1873, from the Oligocene of the Trelissic Basin, N.Z. Although regarded as a synonym of *'Psammechinus' woodsi* Laube by Hutton (1887; Tate 1894), the species has subsequently afforded the record of the genus *Grammechinus* from New Zealand (Hawkins *in* Mortensen 1925; Fell 1953). *Goniosigma* is diagnosed as possessing smooth tubercles and differing from *Grammechinus* in 'having the small secondary tubercles of the interradial (admedian) angles of the interamb plates arranged in vertical zig-zag series, parallel to the adradial sutures . . .' Hutton's original specimen alone was available to Fell in proposing this genus.

In the present study it was found that secondary granules and ridges in the interambulacral midzone aligned parallel to median sutures occur in many Tertiary species (e.g. *Cryptechinus humilior*, Pl. 3, fig. 4; *Asaphechinus murrayensis*, Pl. 5, fig. 6; *Asaphechinus princeps*, Pl. 5, fig. 10). It is apparently an extremely variable growth feature of the test, developed in some large individuals of these species. It cannot be said to be fully characteristic of any of the Australian species. Accordingly it is concluded that *Goniosigma* is based on an evanescent feature of slight taxonomic value. The status of *Goniosigma* must remain in doubt until such time as the nature of the apical system, the character of the ambulacra, the gill slits and the perignathic girdle become known. As the tubercles are described as smooth it does not appear to be synonymous with any of the Australian genera proposed here.

Grammechinus meridionalis sp. nov.

(Pl. 4, fig. 10-13; Pl. 14, fig. 5-6; Fig. 2h)

DIAGNOSIS: A species of *Grammechinus* lacking depressions in the horizontal sutures, but with bosses of the primary tubercles scalloped.

MATERIAL: Seven tests, one with apical system.

TYPE SPECIMEN: Holotype P19211, a laterally compressed test, partly enveloped in limestone matrix, from the 'lower beds, Aldinga'. The matrix indicates that the specimen was derived from the Port Willunga Beds of Janjukian to Batesfordian age.

DESCRIPTION: The test is relatively large and rounded in outline, with a flattened adoral surface which is slightly concave around the peristome. The gill slits, although small, are fairly sharp and well buttressed.

The apical system is regularly dicyclic with the madreporite not enlarged, although the raised, porous area extends over most of genital 2. The surface is poorly preserved, but a circlet of secondary tubercles around the peristome is visible on the genital plates.

The ambulacra are about half the width of the interambulacra, with a fairly wide poriferous tract. The primary ambulacral tubercles form a regular series close to the poriferous tract, leaving a wide median ambulacral zone. Within each triad the pore-pairs are strongly arcuate and are separated by ill-defined ridges radiating from the base of the boss of the primary tubercle. The pores are round and well separated in each pair, with the wall between rising to a well marked elevation. On each plate an enlarged secondary tubercle is present inside the primary tubercle so that a horizontal series is present on each plate.

The interambulacral columns possess regular vertical series of median primary tubercles, similar in size to the corresponding ambulacral tubercles. A horizontal series of up to six secondary tubercles may be present on each interambulacral plate at the ambitus. As with the ambulacra, the rest of the surface of the test is ornamented with smaller secondary tubercles and irregular granules among which are small shallow pits. The tubercles are smooth with narrow parapets which are overhung by the large, almost spherical mamelons. The bases of the bosses are irregularly scalloped.

Measurements:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
AUGD17024	37·0 mm	15·0 mm	10·5 mm	12·0 mm	24	18
P19211	35·0	20·0	—	12·0	25	20
P20213	29·0	16·0	7·0	9·5	19(20)	15

Synopsis of Material: AUGD17024-5, and 3 other tests, R. J. Foster Coll. 'Whitton Bluff', Blanche Point Marl, Upper Eocene; P19211, P20213, 'low beds, Aldinga', Port Willunga Beds, Janjukian to Batesfordian.

Remarks: Cursory examination of this species immediately suggests a comparison with *Asaphechinus* which contains large forms with buttressed gill slits and arcuate pore-pairs. However, the smooth tubercles of *Grammechinus meridionalis* indicate no close relationship here. Furthermore, the arcuate triads of *Grammechinus* are different from those seen in *Asaphechinus*. In the present species the primary ambulacral tubercles are mounted adjacent to the poriferous tract, and the lower pore-pair is inwardly displaced beneath the primary tubercle. A small secondary tubercle is usually present outside the pore-pair of the lowermost component of each triad. In *Asaphechinus* the primary ambulacral tubercle is well separated from the poriferous tract, and a small primary tubercle is generally mounted between the median component of each triad and the primary tubercle.

G. meridionalis differs from *G. regularis* Duncan and Sladen in the smaller gill slits and the absence of depressed horizontal sutures. The scalloping of the bosses of the primary tubercles, as seen in *G. meridionalis*, is not shown in Duncan and Sladen's (1885; Pl. 13, fig. 8) enlargement of the surface detail of their species.

Genus **Ortholophus** Duncan

Ortholophus Duncan 1887, p. 414.
Ortholophus Duncan 1889, p. 100.
Coptechinus Cotteau, Bittner 1892, p. 339 (*partim*).
Paradoxechinus Laube, Tate 1892, p. 191 (*partim*).
Prionechinus A. Agassiz, Lambert and Thiéry 1910, p. 230 (*partim*).
Paradoxechinus Laube, Mortensen 1943a, p. 350 *et seq.* (*partim*).
Pseudechinus Mortensen, H. L. Clark 1946, p. 323 (*partim*).
Brochopleurus Fourtau, Fell 1949, p. 17 *et seq.* (*partim*).
Irenechinus Fell 1964b, p. 211 *et seq.*; Fell 1964a, p. 202; Fell and Pawson 1966, p. 423.
Paradoxechinus Laube, Fell and Pawson 1966, p. U424 (*partim*).

Type Species: *Temnechinus lineatus* Duncan, by monotypy. The type species of *Irenechinus* Fell is *I. hentyi* Fell (= *Coptechinus pulchellus* Bittner, *fide* Philip 1966) by original designation.

Diagnosis: Moderate sized, sculptured temnopleurids with faintly crenulate tubercles, uniserial ambulacra and obscure gill slits. The apical system is regularly dicyclic. Juveniles are strongly sculptured, the sculptural ridges being lost with growth to varying degrees in different species, the obscurely sculptured forms being closely tuberculated. The girdle consists of rather low auricles, with or without capping (Hawkins 1934, p. 622), united above the ambulacra.

Remarks: Much of the past uncertainty as to the application of this genus stems from Duncan's original description of the type species, the discrepancies in which were originally pointed out by Bittner (1892). Duncan gave his genus as sculptured by a net-work of 'ridge-like costae', but his figure of the type specimen of *O. lineatus* shows no trace of sculpture. The above diagnosis has been expanded to cover the several different species here included in the genus.

Together with *Coptechinus*, from the Tertiary of Europe, *Ortholophus* has long been considered a synonym of *Paradoxechinus. Coptechinus* differs in possessing smooth tubercles and has secondary ornament of granules rather than tubercles. *Paradoxechinus* (q.v.) is characterized by the sexual dimorphism of the test.

A review of the past confusion of Australian Tertiary species of *Ortholophus* (with crenulate tubercles) and the Indian and Egyptian Miocene genus *Brochopleurus* (with smooth tubercles) and the resultant erection of *Irenechinus* Fell, has been given elsewhere (Philip 1966).

Two species groups can be distinguished in the Australian Tertiary forms here referred to *Ortholophus*. These are:

1. *O. bittneri—O. morganensis—O. venustus* group in which mature specimens are strongly sculptured.
2. *O. woodsi—O. pulchellus—O. lineatus* group in which the highly developed sculpture of juveniles is lost, or becomes much less obvious during growth.

Some gradation between the groups is seen in species *O. lineatus* and *O. venustus,* but extremes (such as *O. pulchellus* and *O. morganensis,* which occur together in the Morgan Limestone) are so dissimilar in their appearance, that their reference to the one genus might be questioned. However, the differences are based on distinctions in the sculpture, and no fundamental characters permit separation of the species.

The known stratigraphic ranges of the various species in the Australian Tertiary are given in Fig. 4.

Outside of the Tertiary of SE. Australia *Ortholophus* occurs in the Oligocene of New Zealand, for *Irenechinus minor* Fell (1964a, p. 202-203; Pl. 2, figs. 3-4) is clearly referrable to *Ortholophus*. The species apparently belongs to the *woodsi*-

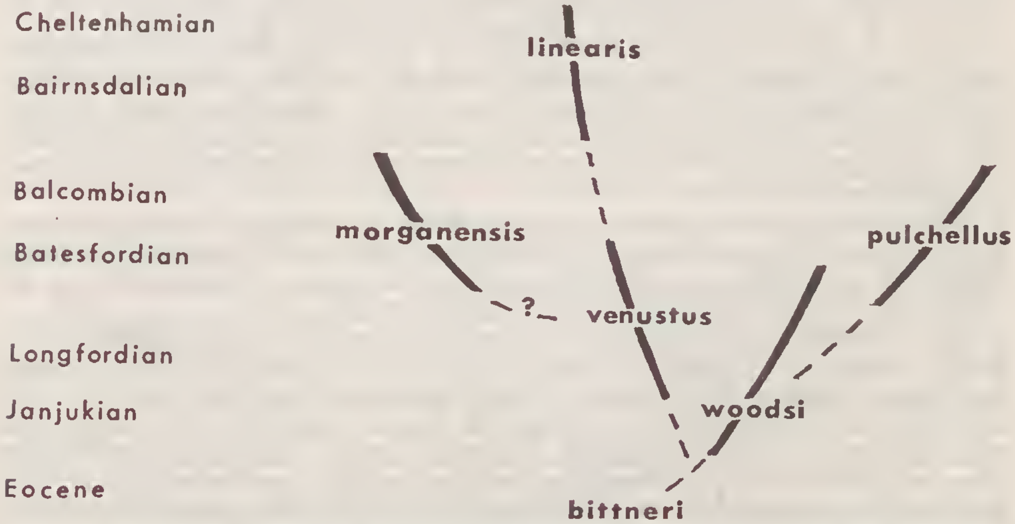

FIG. 4—Stratigraphic and possible phylogenetic relationship of the Australian Tertiary species of *Ortholophus*.

pulchellus species group, but, as it is based on a single immature specimen, little more can be added concerning its relationship to the Australian species.

Ortholophus lineatus (Duncan)

(Pl. 7, fig. 14-18; Pl. 9, fig. 10; Pl. 12, fig. 6; Fig. 5g, i)

Temnechinus lineatus Duncan 1877, p. 46; Pl. 3, figs. 3-5.
Ortholophus lineatus (Duncan), Duncan 1887, p. 413-414; Duncan 1889, p. 101; Tate 1891, p. 274.
Paradoxechinus novus Laube, Tate 1892, p. 191-192 (*partim*).
Prionechinus lineatus (Duncan), Lambert and Thiéry 1910, p. 230.
Paradoxechinus novus Laube, H. L. Clark 1946, p. 308 (*partim*).
(*Non*) *Paradoxechinus novus* Laube 1869, p. 188, fig. 2.
(*Nec*) *Ortholophus lineatus* (Duncan), *sensu* Bittner 1892, p. 338. *et seq.*
(*Nec*) *Coptechinus lineatus* Bittner, *loc. cit.*
(*Nec*) *Paradoxechinus lineatus* (Duncan), Mortensen 1943a, p. 351, fig. 210b-c.

DIAGNOSIS: A species of *Ortholophus* with coarsely sculptured early growth stages which give rise to adults with poorly defined sculptural ridges and rather distant secondary tubercles.

MATERIAL: Five poorly preserved tests lacking apical systems.

TYPE SPECIMEN: The holotype is that specimen originally figured by Duncan from 'Mordialloc, No. 1'. It is a worn and imperfect test, but the surface ornament is retained on one side. The matrix is of a buff-coloured limestone, so presumably the specimen was from a nodule from within the Mordialloc Beds. The specimen, originally in the Geological Society of London Collections, is now catalogued as BM GSL14078.

DESCRIPTION: The test is of moderate size, with a rounded outline and a slightly flattened adoral surface. The peristome is small and the gill slits obscure. The perignathic girdle is known in only one immature specimen where it consists of low uncapped auricles united above the ambulacra and connected by relatively high apophyses. The ambulacra are relatively wide, about three quarters of the width of the interambulacra. The pore-pairs are uniserial and arranged in very weak arcs in each echinoid triad. The primary ambulacral tubercles are mounted close to the poriferous tracts, and two low ridges, radiating from the primary tubercle, separate the pore-pairs in each triad. At the ambitus the primary tubercle is joined on each plate by a slightly enlarged secondary tubercle in the wide median ambulacral zone. Adorally the ambulacral plates tend to be crowded and the pore-pairs there are reduced in size.

The interambulacra possess a regular series of primary tubercles mounted slightly adradially in each column. Toward the ambitus each interambulacral plate possesses a horizontal series of slightly enlarged secondary tubercles, two on the median side of the primary tubercle and one adradially.

The primary tubercles, which form regular vertical series, are imperforate and faintly crenulate. The surface of the test is covered by small secondary tubercles and elongate granules which tend to radiate from the primary tubercle giving the impression of vertical ridges connecting the primary tubercles. The base of the boss of the primary tubercles may be scalloped by these. Irregular pits and depressions occur on the surface of the plates between the ridges and secondary tubercles. In immature specimens double sculptural ridges bearing secondary tubercles zigzag across the ambulacral and interambulacral midzones, but this pattern is obscured during growth.

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
BMGSL14078	15·0 mm	9·0 mm	*c* 3·5 mm	5·0 mm	14	13
BME17857	12·5	6·5	*c* 4·0	5·5	11(12)	10(11)
P23981	8·5	5·0	—	3·5	11	10

SYNOPSIS OF MATERIAL: 'Orbost', i.e. equivalents of the Bairnsdalian Bairnsdale Limestone, P18431. From the Cheltenhamian Sandringham Sands: Holotype; P23988, BME17857, 'Beaumaris', P23981 'Loose in shingle'.

REMARKS: In its sculpture this form appears to be intermediate between *O. woodsi* and *O. venustus*. The holotype is to be distinguished from *O. woodsi* by the more sparse secondary ornament, and the persistence of vague sculptural ridges in what is apparently a mature specimen. The sculpture of immature specimens is similar to that of *O. venustus*.

Ortholophus bittneri nom. nov.

(Pl. 11, fig. 13-21; Pl. 13, fig. 2-3, 5-7; Fig. 6c, e, i-j)

Coptechinus lineatus Bittner 1892, p. 338-341; Pl. 1, fig. 4.
Paradoxechinus novus Laube, Tate 1892, p. 191-192 (*partim*).
Paradoxechinus lineatus (Bittner), Lambert and Thiéry 1910, p. 230.
Paradoxechinus lineatus (Duncan), Mortensen 1942a, p. 351, fig. 210b (*partim*), c, d (*partim*).
Paradoxechinus novus Laube, Fell and Pawson 1966, fig. 317 (1a), (*non*) 1b.
(*Non*) *Temnechinus lineatus* Duncan 1877, p. 46; Pl. 3, fig. 3-5.
= *Ortholophus lineatus* (Duncan), Duncan 1887, p. 413-414.
(*Nec*) *Paradoxechinus novus* Laube 1869, p. 188, fig. 2.

DIAGNOSIS: A species of *Ortholophus* with a somewhat pentagonal outline and strongly developed zig-zag sculptural ridges. The apical system has a small porous area and the genital pores are small and slit-like.

MATERIAL: Forty-four tests, many with apical systems.

TYPE SPECIMEN: Of Bittner's three original specimens, that illustrated in his Pl. 1, fig. 4 is here chosen as lectotype. The specimen is lost (I, p. 183). Bittner notes that his specimens 'sind grünlich gefärbt' which suggests that they were derived from the Tortachilla Limestone. As neotype P20488 is here selected. This test is from the Tortachilla Limestone, and conforms closely with the lectotype.

DESCRIPTION: The test is somewhat pentagonal in outline and possesses flattened adoral and adapical surfaces. The peristome is small and the gill slits are obscure. The girdle consists of relatively wide, spatulate auricles united above the ambulacra, and connected by narrow apophyses.

The apical system is small and dicyclic, with the posterior oculars slightly more insert than the anterior. The madreporite is not enlarged and the porous area is small. The genital pores are small and may be slit-like. The plates are covered with irregular sculptural ridges and irregular granules of which the series bordering the periproct are the best defined. The ambulacra are about half of the width of the interambulacra, and possess narrow poriferous tracts in which the pores are uniserial or obscurely arcuate in each echinoid triad. The pore-pairs are small and tend to be sunken in the 'epistroma' surrounding the primary ambulacral tubercles which form regular vertical series close to the poriferous tracts.

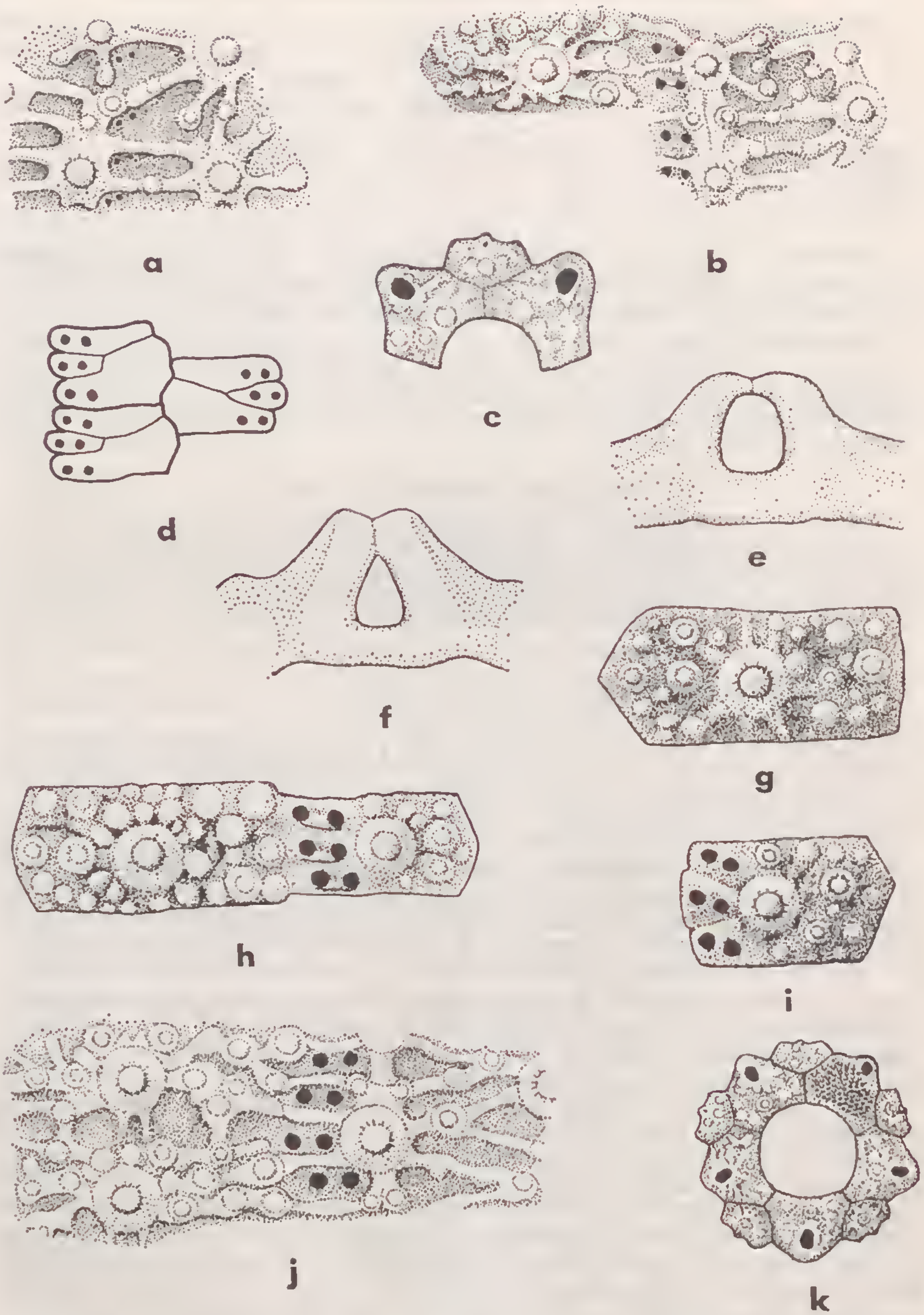

FIG. 5—a-e, h, *Ortholophus woodsi* (Laube). a, Ambital sculpture of a very small specimen (P18331), × 25. b, Ambital sculpture of a moderately large specimen (P18332), × 15 approx. c, Portion of apical system of a small specimen showing sculpture (P18269), × 15. d, Analysis of ambulacral plating (P18177), × 10. e, Auricles (P18268), × 10. h, Ambital plates of a large specimen (P18176), × 15. f, j-k, *Ortholophus pulchellus* (Bittner). f, Auricles (P17987), × 10. j, Ambital sculpture of a large specimen (P17983), × 15. k, Apical system (P17980), × 10. g, i, *Ortholophus lineatus* (Duncan). g, Ambital interambulacral plate of holotype (BM, GSL14078), × 15. i, Ambital ambulacral plate of holotype, × 15.

The interambulacra have a similar vertical series of imperforate, faintly crenulate, primary tubercles. The secondary ornament consists of prominent raised tuberculate ridges connecting the primary tubercles in each vertical series, and zigzagging between the primary tubercles in each zone. From each primary interambulacral tubercle several ridges are present running adradially across the primary ambulacral tubercles between pore-pairs. The sculpture varies considerably in its detail (Pl. 13, fig. 2-3, 5-7).

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P19237	10·5 mm	7·0 mm	3·5 mm	3·5 mm	13	12
P20489	10·0	6·0	3·5	—	12	11
P20488	12·5	8·0	4·0	4·5	12	11

SYNOPSIS OF MATERIAL: Upper Eocene Tortachilla Limestone, 'Aldinga': P20488-90; P19237-8; P20223-4; P19213; P20473-4; UNE10565-9 and 29 other specimens R. J. Foster Coll.

REMARKS: The sculpture of the test of this species recalls to a remarkable degree that seen in the species *Dictyopleurus ziczaz* and *Dictyopleurus haimei* Duncan and Sladen (1882; Pl. 9, figs. 1-5), from the Eocene and Sind, but no close relationship between Australian and Indian forms can be suggested for *Dictyopleurus* is a glyphocyphid. The range of variation seen in the sculpture of *O. bittneri* is considerably greater than that illustrated by Duncan and Sladen as distinguishing their two species.

Because of the contradiction between Duncan's figures and description of his *Ortholophus lineatus*, Bittner was unable to decide whether this species was different from Duncan's species. In view of this (and also because of his uncertainty as to the generic placement of the species) he attributed the authorship of *Coptechinus lineatus* to himself, thus creating a primary homonym, which is corrected above.

Ortholophus morganensis sp. nov.

(Pl. 7, fig. 1-13; Fig. 6a-b, h)

Paradoxechinus novus Laube, Tate 1892, p. 191-192 (*partim*).
(*Non*) *Paradoxechinus novus* Laube 1869, p. 188, fig. 2.

DIAGNOSIS: A large, strongly sculptured species of *Ortholophus* with high sculptural ridges. The interambulacral midzones are slightly sunken. The auricles are capped.

MATERIAL: Twenty-six tests, several with apical systems.

TYPE SPECIMEN: Holotype P17997, from the mid-Miocene Morgan Limestone at Morgan.

DESCRIPTION: The test is rather large and high with a flattened adoral surface which may be slightly concave around the peristome. On the larger specimens the interambulacral midzones are depressed. The gill slits are obscure and the girdle is of delicate capped auricles united above the ambulacra and connected by low apophyses.

The apical system is regularly dicyclic, usually with rounded genital pores

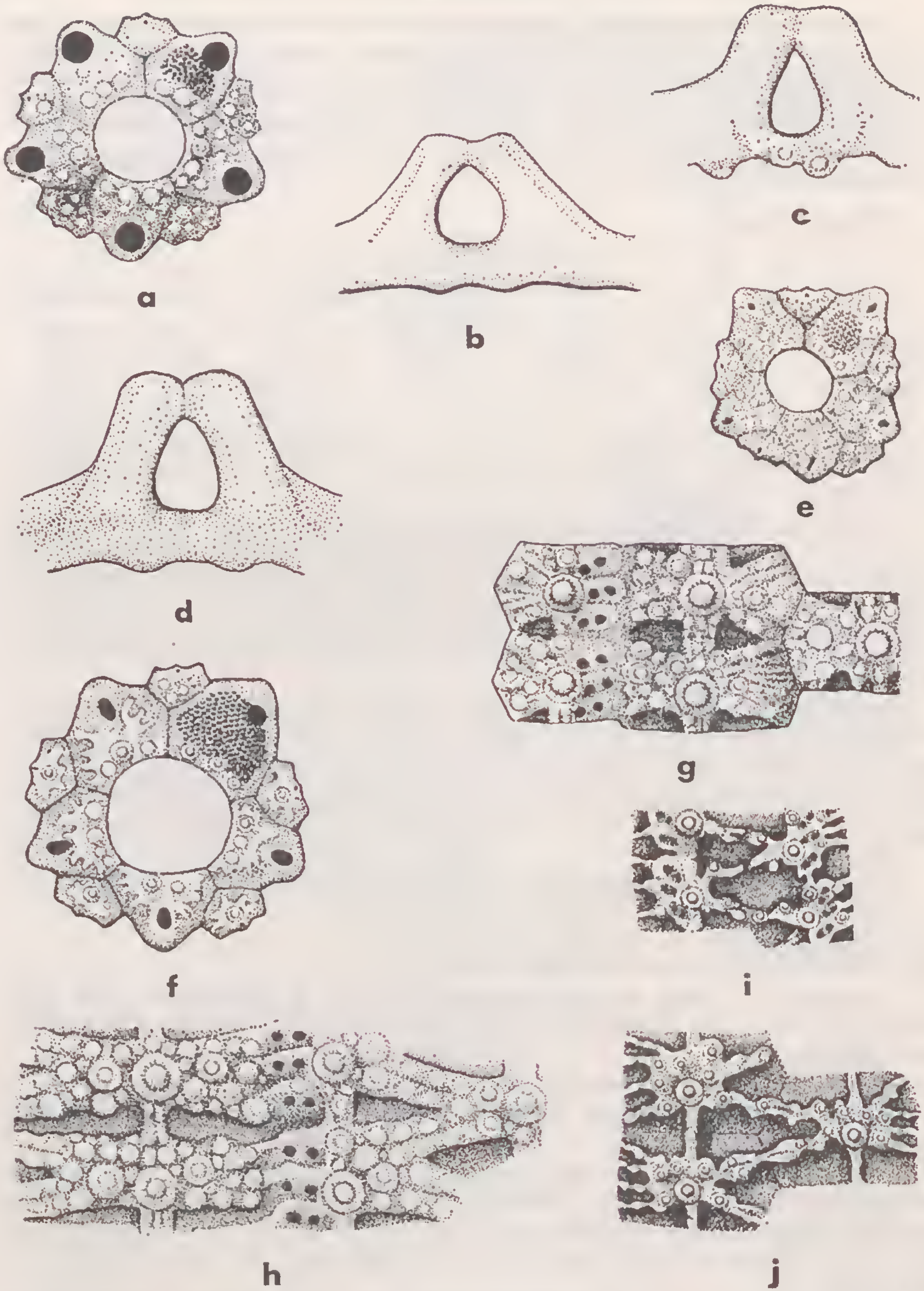

FIG. 6—a-b, h, *Ortholophus morganensis* sp. nov. a, Apical system of holotype (P17997), × 6. b, Auricles (P18002), × 10. Ambital sculpture (P17998), × 10. c, e, i-j, *Ortholophus bittneri* nom. nov. c, Auricles (P20473), × 10. e, Apical system (P20488), × 10. i-j, Ambital ambulacral and interambulacral sculpture of same specimen, × 10. d, f-g, *Ortholophus venustus* sp. nov. d, Auricles (MUGD3493), × 15. f, Apical system (P20124), × 12. g, Ambital ambulacral and interambulacral plates (P20124), × 12.

which are markedly enlarged in one specimen. The madreporite is not noticeably enlarged. The genitals bear a series of secondary tubercles and granules which border the periproct, and are obscurely sculptured. The oculars are closely ornamented with secondary tubercles and granules.

The ambulacra are about three quarters of the width of the interambulacra and possess narrow poriferous tracts in which the pore-pairs are uniserial. The pore-pairs tend to be separated by high, transverse sculptural ridges. The primary tubercles form regular vertical series adjacent to the poriferous tracts.

The interambulacra also possess regular vertical series of faintly crenulate primary tubercles, which, in larger specimens, are to the adradial side of the columns, leaving wide median interambulacral zones.

The sculpture is of very thick ridges, which are usually coalesced to form wide, coarsely tuberculated bands zig-zagging between the primary tubercles of each ambulacral and interambulacral zone; similar broad bands run vertically between the primary tubercles of each column.

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P17998	18·5 mm	13·0 mm	5·0 mm	6·5 mm	14(15)	16
P17997	16·5	11·5	5·5	5·5	14	14(15)
P18000	15·0	10·5	5·0	5·5	14	14
P17999	14·0	8·5	4·0	5·0	12(13)	13(14)
P18001	9·0	5·0	3·0	3·5	10	9(10)

SYNOPSIS OF MATERIAL: P17997-18015, 'Morgan', Morgan Limestone of Batesfordian or Balcombian age. One specimen in AUGD collections from 'Murray River Cliffs', and 7 specimens R. J. Foster Coll. from localities in the Morgan Limestone.

REMARKS: This form is undoubtedly closely allied to *O. venustus*, but may be distinguished by the larger size, the much coarser sculpture, the more highly ornate apical system, and the depressed interambulacral midzones.

Ortholophus pulchellus (Bittner)

(Pl. 10, fig. 1-14; Pl. 15, fig. 1; Fig. 5f, j-k)

Coptechinus pulchellus Bittner 1892, p. 342-344; Pl. 1, fig. 6.
Psammechinus woodsi Laube, Tate 1892, p. 191 (*partim*).
Arbacina pulchella (Bittner), Lambert and Thiéry 1910, p. 231.
Paradoxechinus pulchellus (Bittner), Mortensen 1943a, p. 351, fig. 210b, d. (*partim*).
Progonechinus pulchellus (Bittner), Mortensen *op. cit.*, p. 367.
Pseudechinus woodsi (Laube), H. L. Clark 1946, p. 323-324 (*partim*).
Irenechinus hentyi Fell 1954b, p. 211-213; Pl. 1; Fell and Pawson 1966, fig. 315(5) (inverted).
Ortholophus pulchellus (Bittner), Philip 1966, p. 116.

DIAGNOSIS: A low moderate sized species of *Ortholophus* with delicate sculpture which persists on quite large individuals; bare depressed areas are developed along the horizontal sutures. The auricles are capped.

MATERIAL: Twenty-two tests, 6 with apical systems.

TYPE SPECIMEN: Bittner based this species on three specimens which are now lost. As lectotype the specimen illustrated in his Pl. 1, fig. 5 is here chosen. The lectotype is lost. Although Bittner's description and figures leave little doubt as to the identity of the species, to avoid subsequent confusion it is necessary for a neotype to be chosen. Accordingly P17983 is so designated. It is from the Morgan Limestone (certainly the type formation) at Morgan, of Batesfordian or Balcombian age. The holotype of *Irenechinus hentyi* is P16409 from the Batesfordian Bochara Limestone.

Description: The test is moderately large and depressed with a flattened adoral surface. The peristome is small and the gill slits obscure. The auricles meet above the ambulacra and are connected by well developed apophyses.

The apical system in small specimens is regularly dicyclic, with irregular tuberculation and weakly defined sculptural ridges. In larger specimens the plates are ornamented with closely spaced secondary tubercles and granules which cover the oculars and the proximal portion of the genitals; ocular I may be insert (Pl. 15, fig. 1). The genital pores may be slightly ovate and are relatively large.

The ambulacra are about two thirds of the width of the interambulacra. The poriferous tract is narrow, and the pore-pairs are uniserial, although in larger specimens there is a tendency for a secondary tubercle to be mounted outside the pore-pair of the lowermost component of the ambital ambulacral plates, so that the lowermost pore-pair is inwardly displaced. The primary ambulacral tubercles form regular vertical series.

The interambulacra possess regular series of faintly crenulate, imperforate tubercles. The secondary tubercles and granules are small and closely spaced, and tend to be mounted on sculptural ridges even in apparently mature specimens. The horizontal sutures are naked and depressed in all but the smallest specimens. These depressions may be crossed by two or three thread-like ridges arising from the bosses of the upper tubercles.

Measurements:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P17979	5·5 mm	3·5 mm	2·5 mm	3·0 mm	8	9
P17980	7·5	5·0	2·5	3·5	9	10
P17981	8·5	5·0	2·5	4·0	10	10(11)
P17982	10·5	6·0	3·5	4·5	11	11(12)
P17985	12·0	7·0	3·0	4·5	12	12(13)
P17983	12·0	7·0	3·5	5·0	13(14)	13(14)
P17984	14·0	8·0	3·5	5·0	14	15
P17986	14·0	8·0	4·5	5·5	13(14)	14
P17931	17·0	11·0	4·5	5·5	14	15

Synopsis of Material: From the Morgan Limestone of Batesfordian or Balcombian age: 'Morgan', P17979-96, AUGD17027 (*ex* R. J. Foster Coll.); 'Overland Corner', P17931, and three specimens *ex* R. J. Foster Coll.

Remarks: The beautiful radiating sculpture of this species persists to quite advanced growth stages, so that it is seen far more often than in *O. woodsi*. However, in extremely large specimens, with increase in the secondary tubercles, pits between the tubercles may be all that remains of the sculpture on the plates. However, the bare depressions along the interambulacral sutures are a constant feature of the species and serve to distinguish *O. pulchellus* from typical specimens of *O. woodsi*. It must be noted, however, that several specimens in the collection from the Mannum Formation possess sculpture approaching that of *O. pulchellus* (e.g., Pl. 15, fig. 5). For the present these are referred to *O. woodsi*, but it is possible that they represent forms transitional between the two species. Closely controlled stratigraphic collecting of these species from the strata along the Murray River Cliffs will be necessary before their distribution and relationship is properly understood. The available material suggests that *O. woodsi* is confined to the Mannum Formation and is replaced by *O. pulchellus* in the overlying Morgan Limestone.

Philip (1966) has indicated that *Irenechinus hentyi* Fell must be regarded as a subjective synonym of *O. pulchellus*. Indeed, the synonymy of this species shows a remarkable lack of agreement concerning the generic position of this species. For nine authors there are eight generic locations.

Ortholophus venustus sp. nov.

(Pl. 9, fig. 1-7, 9, 11-14; Fig. 6d, f-g)

DIAGNOSIS: A small species of *Ortholophus* in which adult specimens are sculptured by zig-zagged coalescent ridges, leaving triangular depressions along the horizontal sutures. The auricles are uncapped.

MATERIAL: Seventeen tests, four with apical systems, and many test fragments.

TYPE SPECIMEN: The holotype is MUGD3492, a test from Brock's Quarry, Glencoe, from the Gippsland Limestone of Batesfordian age.

DESCRIPTION: The test is of moderate size, with a slightly flattened adoral surface. The gill slits are obscure. The girdle consists of rather high delicate auricles, lacking capping, which just meet above the ambulacra.

The apical system is regularly dicyclic, and is only slightly sculptured. The genital pores are slightly tear-shaped. On the genitals, the secondary tubercles, granules and obscure sculpture are confined to a zone encircling the periproct, leaving bare the extremities of the genitals. Each of the oculars bears a slightly enlarged secondary tubercle, and may be obscurely sculptured.

The ambulacra are about three quarters of the width of the interambulacra. The poriferous tracts, in which the pore-pairs are uniserial, are narrow, and the regular series of primary ambulacral tubercles are mounted close to these.

The interambulacra also possess a regular vertical series of primary tubercles. Adapically, bare unornamented zones along the median interambulacral sutures are variably developed.

The sculpture is of coarse, high ridges, which persist in fully grown specimens. Double or triple ridges zig-zag between the primary tubercles of both the interambulacral and ambulacral zones, and two or three similar ridges, crossing the bare horizontal sutures, tend to connect the primary tubercles in each column. The variation in sculpture is illustrated in Pl. 9, fig. 9, 11-14.

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P20124	13·5 mm	9·0 mm	3·5 mm	5	12	13
MUGD3492	11·7	7·0	3·0	4	11	11(12)

SYNOPSIS OF MATERIAL: P20124, 'Longford', Longford Limestone, Longfordian. P18745-58, 'Mouth of Spring Creek', '*Scutellina*' Limestone, Longfordian. From the Gippsland Limestone of Batesfordian age: MUGD3492-3, Brock's

Quarry, Glencoe. GSV57425 (5 test fragments), 'Marl pit 250 yds W. of Brocks'. GSV57429 (4 test fragments); GSV57428 (2 tests and 2 test fragments), 'Le Grand's quarry, Glencoe'.

REMARKS: The only reasonably preserved specimen from the *'Scutellina'* Limestone in the Torquay sequence differs slightly from the Gippsland specimens in the character of the sculpture, particularly in the less strongly developed bare areas along the horizontal sutures, and the poorly defined sculptural ridges. It thus approaches more closely the *O. woodsi* type of ornament. Should this specimen prove fully typical of the *'Scutellina'* Limestone form, then this could be separated as a subspecies of *O. venustus*.

Ortholophus woodsi (Laube)

(Pl. 8, fig. 1-16; Pl. 12, fig. 2; Pl. 13, fig. 1; Pl. 14, fig. 4; Pl. 15, fig. 3, 5; Fig. 5a-e, h)

?? *Echinus* Sturt 1834; Pl. 3, fig. 11.
Psammechinus Woodsi Laube 1869, p. 185-186, fig. 1-1b.
Psammechinus Woodsi Laube, Etheridge 1875, p. 447; Pl. 11, fig. 10-10a; Duncan 1877, p. 64.
Arbacina Woodsi (Laube), Pomel 1883, p. 85.
Psammechinus Woodsi Laube, Duncan 1887, p. 413; Tate 1891, p. 274; Bittner 1892, p. 334-336; Pl. 1, fig. 1-2.
Psammechinus Woodsi var. *fascigar* Bittner, *loc. cit.*
Psammechinus Woodsi Laube, Tate 1892, p. 191 (*partim*).
Prionechinus Woodsi (Laube), Lambert and Thiéry 1910, p. 230.
? *Psammechinus woodsi* Laube, Chapman 1914, p. 145, fig. 80B.
Pseudechinus woodsi (Laube), H. L. Clark 1946, p. 323-324 (*partim*).
Brochopleurus australiae Fell 1949, p. 18-19; Pl. 1 (*partim*).
Ortholophus woodsi (Laube), Philip 1966, p. 116.

DIAGNOSIS: A large species of *Ortholophus*, often with a high test, and finely sculptured early growth stages which give rise to closely tuberculated adults, lacking sculpture. The auricles are uncapped.

MATERIAL: Two hundred and forty tests, many with apical systems.

TYPE SPECIMEN: The holotype is that specimen originally figured by Laube and is now in the Naturhistorisches Museum, Vienna, where it bears the registration number 9019. It is a high, large test, undoubtedly collected from the Mannum Formation, in which the species occurs in profusion. The holotype of *Brochopleurus australiae* Fell is P4687, again from the Mannum Formation.

DESCRIPTION: The test is moderately large, with a flattened adoral surface, and varies in shape from depressed to subconical. The peristome is small, and the gill slits are obscure. The auricles are low and uncapped, but are united above the ambulacra, and are connected by relatively high apophyses.

The apical system is usually regularly dicyclic, with genital 2 not enlarged, although the madreporic pores may extend over most of its surface. In some specimens (e.g. Pl. 15, fig. 3) ocular I is insert. The genital pores are rather large, and may be somewhat tear-shaped. In the more subconical specimens the periproct is rimmed by the upwardly inflected inner margins of the genitals. In early growth stages the apical system may be strongly sculptured, but, with growth, this gives way to closely spaced secondary tubercles and granules.

The ambulacra are from one to two thirds of the width of the interambulacra. In large specimens the ambulacra may be slightly raised, so in outline the test may become subpentagonal. The poriferous tract is narrow, with the pore-pairs uniserial, or arranged in obscure arcs in each echinoid triad. The primary ambulacral tubercles form regular vertical series very close to the poriferous tracts.

The interambulacra possess regular vertical series of imperforate, faintly crenulate primary tubercles. Elsewhere the surface of the test of mature specimens is ornamented by closely and irregularly placed secondary tubercles and granules between which are irregular depressions and pits.

MEASUREMENTS:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P18331	4·5 mm	2·5 mm	1·5 mm	2·0 mm	5	7
P18332	6·0	3·0	—	3·0	7	8
P18333	6·5	3·5	2·0	2·5	8(9)	10
P18270	8·0	4·5	2·5	3·0	10(11)	11
P18271	12·0	7·0	4·0	4·5	11(12)	13(14)
P18176	14·0	10·5	4·5	5·0	17	15
P18177	14·0	10·0	4·5	5·0	15(16)	16
P18178	14·0	12·0	4·0	4·5	16(17)	15
P18179	19·5	16·5	*c* 6·0	*c* 6·0	19(20)	16(17)
P18180	20·0	14·0	6·0	6·5	18	15(16)
NHV9019	22·5	16·5	5·0	5·5	19(20)	16(17)

SYNOPSIS OF MATERIAL: From the Mannum Formation of Longfordian age: 'Mannum', 17 specimens in AUGD Coll. 'Lower Beds between Mannum and Wongulla', P18331-40; 'Wongulla', P18244, P18268-80; 'Swan Reach, P18176-92, P18234-5, R. J. Foster Coll.: 'Mannum', 43 specimens; 'Left bank, 1½ miles N. of Nildottie', AUGD17023 and 19 other specimens; 'Swan Reach', 48 specimens; Mannum pumping station, AUGD17030; 'Cliff above river road just N. of gate to same', AUGD17028 and one other specimen; 'Kroehe's landing', 10 specimens.

From the Torquay sequence: 'Aircy's Inlet', Pt. Addis Limestone, Janjukian, P18832-5 (worn specimens); 'Polyzoal limestone, beach N. of Bird Rock', i.e. '*Cellepora* Limestone', Zeally Limestone, Longfordian, P18586-90; 'Pt. Danger (? Pt. Danger Clay, Batesfordian), P18609-10.

P18609-10, P19161, Gambier Limestone at Nelson, ? Longfordian. GSV57433 'Par Glencoe, allot. 36', Batesfordian. GSV57428, 'Le Grand's Quarry, Glencoe', Gippsland Limestone, Batesfordian. 'Levi's Creek, near Stonefield', Mt. Lofty Ranges, 6 specimens R. J. Foster Coll.

REMARKS: Most remarkable is the change in the character of the sculpture which took place during the growth of the test of this species; indeed, a small, more highly sculptured specimen was named as a separate species by Fell (1949).

The early growth stages possess a strongly developed system of ridges bearing secondary tubercles and radiating from the primary tubercles; these are gradually lost with increase in size and number of the secondary tubercles and so give way to the close secondary granulation of the adult, in which generally no vestige of the sculptural ridges remains. The bosses of the primary tubercles may, however, be slightly scalloped in the adults. The depressions between the secondary tubercles (often seen in temnopleurids) on the surface of the plates apparently arises from the incomplete closure of the original spaces between the ridges. This introduces the possibility that the phenomenon of loss of sculpture during growth (seen in many of the Australian Tertiary species) may obtain in all of the sculptured temnopleurids which have pits on the plates.

Besides variation in sculpture there is also considerable variation in the height of the test. Bittner proposed the variety *fascigar* for the more depressed forms, the holotype possessing a reasonably high test. This variety could be retained, for no other species of *Ortholophus* shows this variation in shape of the test. It may be noted that Ikeda (1931) maintained that in *Temnopleurus toreumaticus*, which also shows considerable variation in the height of the test, this was due to sexual dimorphism and that the higher tested forms were males. Mortensen (1943a, p. 79), however, was unable to uphold this finding.

In some of the specimens from the Mannum Formation adapically the secondary ornament may be confined to the centres of the plates so that bare interambulacral midzones may be developed (Pl. 14, fig. 4).

The material from the Torquay sequence is unsatisfactory for it contains but few well preserved specimens. Most of the specimens from the *Cellepora* Limestone are indistinguishable from their contemporaries from the Murray River Cliffs. However, one specimen in particular shows considerable enlargement of the secondary tubercles (Pl. 8, fig. 12) and further specimens show a tendency to this feature. It would seem likely, therefore, that the Torquay form may differ slightly from the Murray River Cliffs form, but separation cannot be justified in the available material.

One specimen from Pt. Danger (P18609; Pl. 8, fig. 16) retains what are probably traces of the original coloration of the test. The test is dull purple brown, whereas the mamelons and bosses of the primary and secondary tubercles are creamy white.

The relationship of *O. woodsi* and *O. pulchellus* is discussed under the latter species.

Ortholophus spp. indet.

A number of worn, immature specimens is present in the collection, from localities whence otherwise the genus is not known. They all belong to the *woodsi* species group. The specimens are:
P20099-100, and several specimens in the writer's collection, from the Flinders Limestone at Flinders. P18436, and several specimens in the writer's collection, from the Batesford Limestone at Batesford. P19174-5, P19177, and several specimens in the AUGD collections, from various localities in the Gambier Limestone.

Genus **Paradoxechinus** Laube

Paradoxechinus Laube 1869, p. 186.
Paradoxechinus Laube, Pomel 1883, p. 86.
Paradoxechinus Laube, Duncan 1889, p. 101 (*partim*).
Paradoxechinus Laube, Bittner 1892, p. 339.
Paradoxechinus Laube, Tate 1892, p. 191 (*partim*).
Paradoxechinus Laube, Lambert and Thiéry 1910, p. 230 (*partim*); 1925, p. 570 (*partim*).
Paradoxechinus Laube, Morley Davies 1936, p. 77 (*partim*).
Paradoxechinus Laube, Mortensen 1943a, p. 350 (*partim*).
Paradoxechinus Laube, H. L. Clark 1946, p. 308 (*partim*).
Paradoxechinus Laube, Fell and Pawson 1966, p. U424 (*partim*).

TYPE SPECIES: *Paradoxechinus novus* Laube, by monotypy.

DIAGNOSIS: Small, depressed forms usually with very prominent sculptural ridges bearing secondary tubercles and granules and zig-zagging between the primary tubercles. The pore-pairs are uniserial and are embedded in the raised 'epistroma' neighbouring the primary ambulacral tubercles. The primary tubercles are crenulate and the gill slits very shallow. The perignathic girdle consists of relatively large spatulate auricles united above the ambulacra and connected by low apophyses. Apical system unknown; sexual dimorphism notably developed, with the females possessing a wide, deep adapical depression.

REMARKS: Because of the uncertainty as to the limits of the species of Australian Tertiary temnopleurids, this endemic genus has been expanded to include many different forms. Duncan (1887, 1889) considered the European genus *Coptechinus* Cotteau to be a synonym of *Paradoxechinus*. Tate (*loc. cit.*) also submerged *Ortholophus* Duncan in *Paradoxechinus*. Lambert and Thiéry (*loc. cit.*) followed Duncan, and subsequently regarded *Brochopleurus* Fourtau as a synonym of *Paradoxechinus*. Mortensen regarded *Brochopleurus* as a separate genus, but placed both *Ortholophus* and *Coptechinus* in the synonymy of *Paradoxechinus*, which also appears to have been the intention of H. L. Clark. Fell and Pawson (*loc. cit.*) follow Mortensen's usage.

All the above mentioned genera are here regarded as discrete (see discussion of *Ortholophus*). The notable feature of *Paradoxechinus* which distinguishes it from other temnopleurids is the character of the sexual dimorphism of the test.

It will be noted that the recent diagnosis of *Paradoxechinus* given by Fell and Pawson (1966) is apparently based largely on *Coptechinus bardini* Cotteau (1883, p. 27; Pl. 4, fig. 3-5) the type species of *Coptechinus*. Hence the tubercles are given as smooth, and it is said that there are no distinct secondary tubercles. The statement that the apical system is regularly dicyclic derives from the species *Coptechinus lineatus* Bittner (*non Ortholophus lineatus* Duncan) (= *Ortholophus bittneri* Philip) which was included in the genus.

Paradoxechinus novus Laube

(Pl. 11, fig. 1-12; Pl. 12, fig. 1; Fig. 7)

Paradoxechinus novus Laube 1869, p. 188, fig. 2.
Paradoxechinus novus Laube, Etheridge 1875, p. 449; Duncan 1877, p. 65; Etheridge 1878, p. 142; Duncan 1887, p. 415.
Paradoxechinus novus Laube, Tate 1891, p. 274 (*partim*).
Paradoxechinus novus Laube, Bittner 1892, p. 344-345; Pl. 4, fig. 4.
Paradoxechinus novus Laube, Tate 1892, p. 192-193 (*partim*).
Paradoxechinus novus Laube, Lambert and Thiéry 1910, p. 230, Mortensen 1943a, pp. 350-351, fig. 210a.
Paradoxechinus novus Laube, H. L. Clark 1946, p. 308 (*partim*).
Brochopleurus australiae Fell 1949, p. 18-19; Pl. 1, (*partim*).
Paradoxechinus novus Laube, Fell and Pawson 1966, fig. 317(1b), (*non*) 1a = *Ortholophus bittneri* Philip.

DIAGNOSIS: As for genus.

MATERIAL: Twenty-three tests, eleven with apical depressions.

TYPE SPECIMEN: The holotype is the specimen originally figured by Laube and is catalogued in the collections of the Naturhistorisches Museum, Vienna, as 9024. The specimen, from the 'Murray cliffs', undoubtedly came from the Mannum Formation of Longfordian age, whence only the species is known to occur.

DESCRIPTION: The test is very low and depressed with a flattened adoral surface which may be slightly concave around the relatively wide peristome. The gill slits are almost wanting. The girdle consists of relatively wide, spatulate auricles united above the ambulacra, and connected by narrow apophyses. A wide adapical depression (described in detail below) is present in some of the specimens.

The ambulacra are about two thirds the width of the interambulacra, with a narrow poriferous tract in which the pore-pairs are arranged in obscure arcs. The primary ambulacral tubercles form regular vertical series close to the poriferous tracts. Typically the pore-pairs are sunken in the raised sculptural 'epistroma' adjacent to the primary tubercles, and so they appear to be conjugate.

The interambulacra possess regular vertical series of primary tubercles mounted

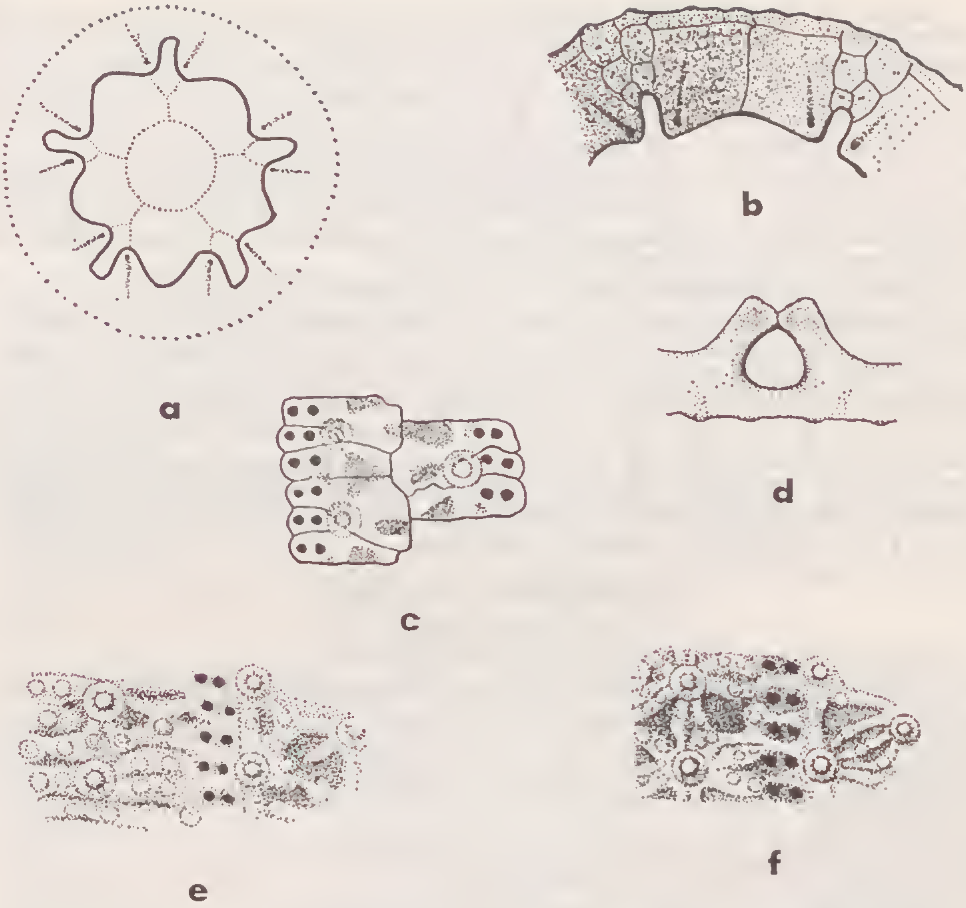

FIG. 7—*Paradoxechinus novus* Laube. a, Outline of margins of the adapical depression with possible plating of a dicyclic apical system (P18243 ♀), × 6. h, Oblique view of plating and ornament within the apical depression (P18243 ♀), × 10. c, Analysis of ambulacral plating (P18223 ♂), × 10. d, Auricles (P18243), × 10. e, Ambital sculpture (P18224 ♂), × 10. f, Ambital sculpture (P18243 ♀), × 10.

toward the centre of each column. Typically the sculpture consists of two irregular strands zig-zagging between the primary tubercles and vertical strands connecting the primary tubercles in each column. The ambulacral midzone is similarly ornamented, and ridges run from the adradial side of the primary ambulacral tubercles to connect with the primary interambulacral tubercles. There is considerable variation in the detail of the sculpture and the ridges may be wide and close, or even merge in smaller specimens. The primary tubercles are faintly, but distinctly, crenulate.

SEXUAL DIMORPHISM: The holotype, and ten other specimens in the present collection, show the remarkable apical depression which has been interpreted by Bittner and Mortensen as a marsupium. None of these specimens show any of the plates of the apical system.

The internal diameter of the depression is from half to two thirds of the diameter of the test and becomes relatively wider during growth. The depression is deep (up to half the height of the test) and sharply bounded by the sudden inflexion of the coronal plates at its borders. The portion of the corona within the depression is slightly concave.

The sculpture and primary tubercles of the test cease abruptly at the margin of the depression and are replaced by granules which become smaller and more distant toward the apical system. In the interradii there are two large interambulacral plates within the depression, while radially there are high, simple ambulacral plates each of which is pierced by a very small pore-pair. At the rim of the depression, these 'immature' ambulacral plates abruptly give way to normal echinoid compound plates. At the apex of each of the interambulacral places within the depression (i.e. to each side of the inferred positions of the oculars) are small pits which do not penetrate to the inside of the test. A shallow groove runs from each of these pits to well up the side of the depression. The inner margins of the depression suggest that the oculars were very elongate (particularly in smaller specimens) and that the apical system was dicyclic.

There can be no doubt that the apical depression of *P. novus* has been correctly interpreted as a marsupium in which the female carried the young. Not only can no other explanation be suggested, but also now specimens have been recognized which do not possess such depressions (i.e. males).

Among sea urchins, brooding of the young is known principally among the cidarids and spatangoids (where the young are carried in the sunken petaloid ambulacra), particularly Antarctic forms. With the sole exception of *Austrocidaris canaliculata* (Agassiz), which bears its young on the apical system, brooding cidarids carry their off-spring around the peristome, protected by the adoral primary radioles. In the other regular echinoids undoubted brooding appears to have been reported only to the Arctic temnopleurid *Hypsiechinus coronatus*, although Gregory (1892b) interpreted the adapical sutural depressions of the British Pliocene species *Temnechinus excavatus* Forbes as 'marsupial pouches' and gave a similar explanation to some obscure adapical interambulacral depressions in *'Echinus' henslovi* Forbes. The same explanation has been given of similar, although better developed adapical depressions in the Cretaceous phymosomatid *Thylechinus said* (Peron and Gauthier) (cf. Mortensen 1935, p. 468, fig. 267a).

The structure of the females of *Paradoxechinus novus* finds its closest analogue in that of the living temnopleurid *Hypsiechinus coronatus*. Here the females possess a prominently elevated apical system in which the plates are strongly inflected to form a distinctive knob. The young are carried around this knob on the adapical surface of the test. The most interesting similarity with the condition of *Paradoxechinus novus* is that the upper interambulacral plates (on which the young are perched) are remarkably high and have lost their primary tubercles, these latter being replaced by small granules (Mortensen 1943a, p. 295, fig. 161). Furthermore, Mortensen's (1943a, p. 45, fig. 42) drawing of the ambulacral structure of *Hypsiechinus coronatus* shows the upper plates to be of simple primaries—presumably similar to those of *P. novus*.

In the females of both *P. novus* and *H. coronatus* the high upper interambulacral plates would seem to afford a barrier preventing the introduction of the new interambulacral plates, so that the number of plates in adult females would remain constant from the onset of sexual maturity and the beginning of the formation of the marsupium. This can be seen from the table of measurements given below; in the males the number of plates increases continually with growth, whereas in the females, after the formation of the marsupium, increase in the size of the corona is achieved solely by increase in the size of the coronal plates. It follows, then, that in mature specimens of comparable size, the plates of the female are relatively higher.

No expalantion can be suggested for the pits toward the margins of the enlarged adapical interambulacral plates.

MEASUREMENTS:

Females:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.*	No. interambs.*
P18243	9·5 mm	4·5 mm	4·5 mm	3·7 mm	7(8)	8(9)
P18266	10·5	5·0	5·2	4·0	7	8(9)
P18175	13·0	6·2	—	*c* 4·5	7(8)	8(9)

* Outside apical depression.

Males:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
P18267	8·0 mm	4·5 mm	*c* 2·5 mm	3·0 mm	7	8
P18222	9·0	4·5	*c* 2·0	3·0	8	10
P18223	11·5	5·5	3·0	4·0	9	10

SYNOPSIS OF MATERIAL: From the Mannum Formation of Longfordian age: 'Lower beds, Swan Reach to Mannum', P18222-5; P18175; 'Wongulla, above Mannum' P18243, P18266-7; 'Left bank, 1½ miles N. of Nildottie', 11 specimens R. J. Foster Coll.; 'Mannum', 2 specimens R. J. Foster Coll.

REMARKS: Some difficulty may be found in distinguishing small specimens of the males of this species from immature specimens of its associate *Ortholophus woodsi*, for the wide variation in the character of the sculpture of *P. novus* can approach that of the small forms of this latter species. Indeed, Fell (1949) in describing an immature specimen of *Ortholophus woodsi* as *Brochopleurus australiae*, included a second specimen in his species which is here interpreted as a male form of *P. novus* (P4688). However, in *O. woodsi* the secondary ornament is much finer, the test is seldom as low, the ambulacra are narrower and there are more coronal plates.

Genus **Pseudechinus** Mortensen

Pseudechinus Mortensen 1903, p. 106.
Pseudechinus Mortensen 1943a, p. 223 *et seq.* (*cum synon*).
Pseudechinus Mortensen, H. L. Clark 1946, p. 323 (*partim*).
Pseudechinus Mortensen, Fell 1958, p. 35; 1960, p. 71.

TYPE SPECIES: *Echinus albocinctus* Hutton by monotypy. Lambert and Thiéry (1914, p. 243) give *Echinus magellanicus* Philippi as the type species but this species is not mentioned by Mortensen in the founding of the genus.

DIAGNOSIS: Small or moderate sized, thin tested forms, usually somewhat hemispherical in shape. The pore-pairs of the ambulacra arranged in distinct arcs of three. The apical system is dicyclic or has the posterior oculars insert. Primary tubercles usually large, and crenulate to varying degrees. The gill slits are shallow. Sculpture is usually completely lacking in adult specimens.

REMARKS: H. L. Clark (*op. cit.*) included the genus *Pseudechinus* in the family Echinidae, although the crenulation of the tubercles in some species speaks strongly against this association. Mortensen, on the basis of the pedicellariae, regarded the genus as a temnopleurid within the subfamily Temnopleurinae. More recently Fell (1958) has found some confirmation of this position for, in describing a new species, *P. flemingi*, he noted the occurrence of 'weak radial sculpture' traces of which were also observed in young specimens of *P. albocinctus* and *P. novaezealandae.*

It is possible that *Pseudechinus* was derived from the older Australian Tertiary temnopleurids, but a number of peculiarities seem to preclude its direct descent from the present-known species. The general appearance of the test, especially the absence of well defined sculpture in mature individuals, recalls the condition of *Asaphechinus*, particularly the early species *A. tasmanensis*. The rather strongly crenulate tubercles of the Miocene representative of *Pseudechinus* described below, would also support such ancestry. But the later species of *Asaphechinus* are larger, more specialized forms, particularly in the character of the gill slits (and, indeed, deepening of the gill slits appears to be progressively developed through the succession of species of *Asaphechinus*).

Another possible ancestor is the genus *Ortholophus* (the range of which *Pseudechinus* overlaps in time). With the loss of sculpture and with the development of arcuate pore-pairs in the ambulacral triads, *Ortholophus* could have given rise to *Pseudechinus* (H. L. Clark 1946, actually regarded the species *Ortholophus woodsi* (Laube) as a species of *Pseudechinus*). However, the rather strongly crenulate tubercles of the Miocene *Pseudechinus* sp. cf. *P. albocinctus* does not support such ancestry.

DISTRIBUTION: Mortensen (1943a) recognized nine species and one variety. Subsequently Fell (1958) described a further species. Some of these forms are based on one or two, probably immature specimens, and so are of doubtful value. Species groups which may be recognized are:

1. *Pseudechinus albocinctus* (Hutton) from New Zealand, with the allopatric forms *P. magellanicus* (Philippi) from S. America and *P. marionensis* Mortensen from the Marion Islands. The recently described *P. flemingi* Fell from the Chatham Islands also appears to be a form closely related to, and allopatric with *P. albocinctus.*
2. *Pseudechinus novaezealandiae* (Mortensen) from southern New Zealand.
3. *Pseudechinus huttoni* Benham [and its probable synonym *P. grossularia* (Studer)], with the allopatric Australian forms *P. notius* (H. L. Clark) and *P. hesperus* H. L. Clark. *P. variagatus* Mortensen would seem to be a further allopatric New Zealand form of this species.

Within New Zealand waters the living species groups appear to be sympatric.

The fossil form *Echinus andinus* Philippi, of uncertain age from Chile (*fide* Mortensen 1943a, p. 226, fig. 199) and included by Lambert and Thiéry (1914) in the genus *Pseudechinus*, would seem to have far too prominent gill slits to be placed here.

H. L. Clark (1946) included the Australian Longfordian species *'Psammechinus' woodsi* Laube in the genus, but this is a species of *Ortholophus* (*q.v.*).

Fell (1953) suggests that the genus probably appeared in the Australian Pliocene and records it from 'corresponding sediments' in New Zealand. Subsequently, in describing his *P. flemingi* (1958, p. 36), he noted that it occurred in 'Castlecliffian (Pleistocene) sediments near Wanganui'. It would seem, therefore, that *P. flemingi* is the form identified by Farquhar (1894, p. 196) and de Loriol (1904, p. 20) as *Echinus albocinctus* Hutton. Farquhar gives the occurrence as from the 'Pliocene formation at Shakespeare Cliff, Wanganui' and de Loriol 'Landguard Bluff près Wanganui'.

The upper Miocene form described below is apparently the oldest known species of *Pseudechinus*.

Pseudechinus albocinctus (Hutton)

Echinus albocinctus Hutton 1873, p. 12.
Pseudechinus albocinctus (Hutton), Mortensen 1943a, p. 227-232; Pl. 47, figs. 25, 31 (*cum synon*).

Pseudechinus sp. cf. **P. albocinctus** (Hutton)

(Pl. 9, fig. 8, 15; Fig. 2d)

Diagnosis: A form apparently identical with *P. albocinctus* but with smaller primary tubercles and more strongly crenulate tubercles.

Material: One broken test (P18367) partially freed from matrix, from 'Toorloo Creek, Toorloo Arm of Lake Tyers', i.e., equivalents of the Bairnsdale Limestone of Bairnsdalian age.

Measurements:

h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
15·7 mm	9·5 mm	4·5 mm	—	16	12

Remarks: This single, imperfect specimen seems to resemble very closely the living New Zealand species with which it is at present compared. Its measurements are remarkably similar to those of the smallest specimen in Mortensen's (1943a, p. 228) table of measurements of *P. albocinctus*. It differs from the Recent species in the less arcuate pore-pairs of the ambulacra and the smaller and more strongly crenulate primary tubercles. Should further material establish these distinctions, then the Australian Upper Miocene form should be separated from the living species.

Genus **Tatechinus** gen. nov.

Type Species: *Tatechinus nudus* sp. nov.

Diagnosis: Medium sized sculptured temnopleurids with strongly crenulate tubercles, the adoral margins of the bosses of which are scalloped. The sculpture is confined to a few elongate granules toward the centres of the adoral plates, and also on the plates of the apical system. Bare median areas extending below the ambitus are present in the ambulacra and interambulacra, and adapically the tuberculation of the interambulacra is confined to the central portion of the plates. The auricles are united above the ambulacra, and the gill slits are poorly defined.

Remarks: Although the bare median areas of the ambulacra and interambulacra are seen in temnopleurids in such genera as *Microcyphus*, *Salmacis* and *Mespilia*, this is their first occurrence in the group of sculptured temnopleurids.

Thus *Tatechinus* stands well apart from other genera of the family. The strong crenulation of the tubercles also serves to distinguish the genus, and thus allies it with *Cryptechinus* and *Asaphechinus*.

The genus is known only from the single Upper Eocene species. As bare unornamented zones of the test are elsewhere regarded as a specialization, it is surprising to find them developed in this early representative of the family.

In the living temnopleurid *Mespilia* Desor, Mortensen (1943a, p. 176-177) notes that the bare zones of the ambulacra and interambulacra are marked by 'whitish spots' made conspicuous by the 'whitish colour on the dark ground colour of the plate'. These radiate from the centre of the plate. Mortensen further adds that 'the whitish colour seems to be due to a structural difference, the calcareous network being more open in the whitish spots and stripes than in the rest of the test'. This condition is similarly manifest in the bare zones of the test of *Tatechinus*, although here the fibres tend to cross the sutures at right angles. However, rather than the condition arising from a 'more open network', it would seem to result from a regular preferred orientation of the fibres parallel to the surface of the plates within the bare zone; elsewhere in the plates (as normally) the calcareous mesh-work is more or less irregular, the orientation of fibres being apparently normal to the surface of the plates.

The genus is named for Professor Ralph Tate, whose contributions to Australian Tertiary palaeontology prior to the turn of the century did much to elucidate the character of the whole fauna.

Tatechinus nudus sp. nov.

(Pl. 4, fig. 7-9, 14-15; Pl. 14, fig. 7; Pl. 15, fig. 4; Fig. 8a-f, i)

Psammechinus Woodsi Laube, Tate 1892, p. 191 (*partim*).
(*Non*) *Psammechinus Woodsi* Laube 1869, p. 185-186, fig. 1-1b.

DIAGNOSIS: As for genus.

MATERIAL: Thirty-five tests, several of which retain apical systems.

TYPE SPECIMEN: Holotype P20212, a large test from 'lower beds, Aldinga', Tortachilla Limestone, Upper Eocene.

DESCRIPTION: The test is moderately large and subconical with a slightly flattened adoral surface which may be slightly concave around the peristome. The peristome is comparatively small. The gill slits are poorly defined. The perignathic girdle consists of strong, flattened auricles united above the ambulacra and connected by rather high apophyses.

The apical system is regularly dicyclic with pores of the madreporite covering most of genital 2. The genitals are ornamented by one to three secondary tubercles and irregular granules which also may be present on the oculars. The genital pores are fairly large and may be somewhat tear-shaped.

The ambulacra are slightly less than half the width of the interambulacra and possess narrow poriferous tracts in which the pore-pairs of each triad are arranged in obscure arcs. The ambulacral plates are very high, particularly adapically. Within the pore-pairs the pores are rather large and rounded, with the wall between rising to a well marked elevation. The primary ambulacral tubercles form regular vertical series close to the poriferous tract, leaving the conspicuous bare median zone of the ambulacra which extends down below the ambitus. The secondary ornament of the plates possesses but a few secondary tubercles and granules. The granules extend from the ornamented portion of each plate onto the poriferous tract.

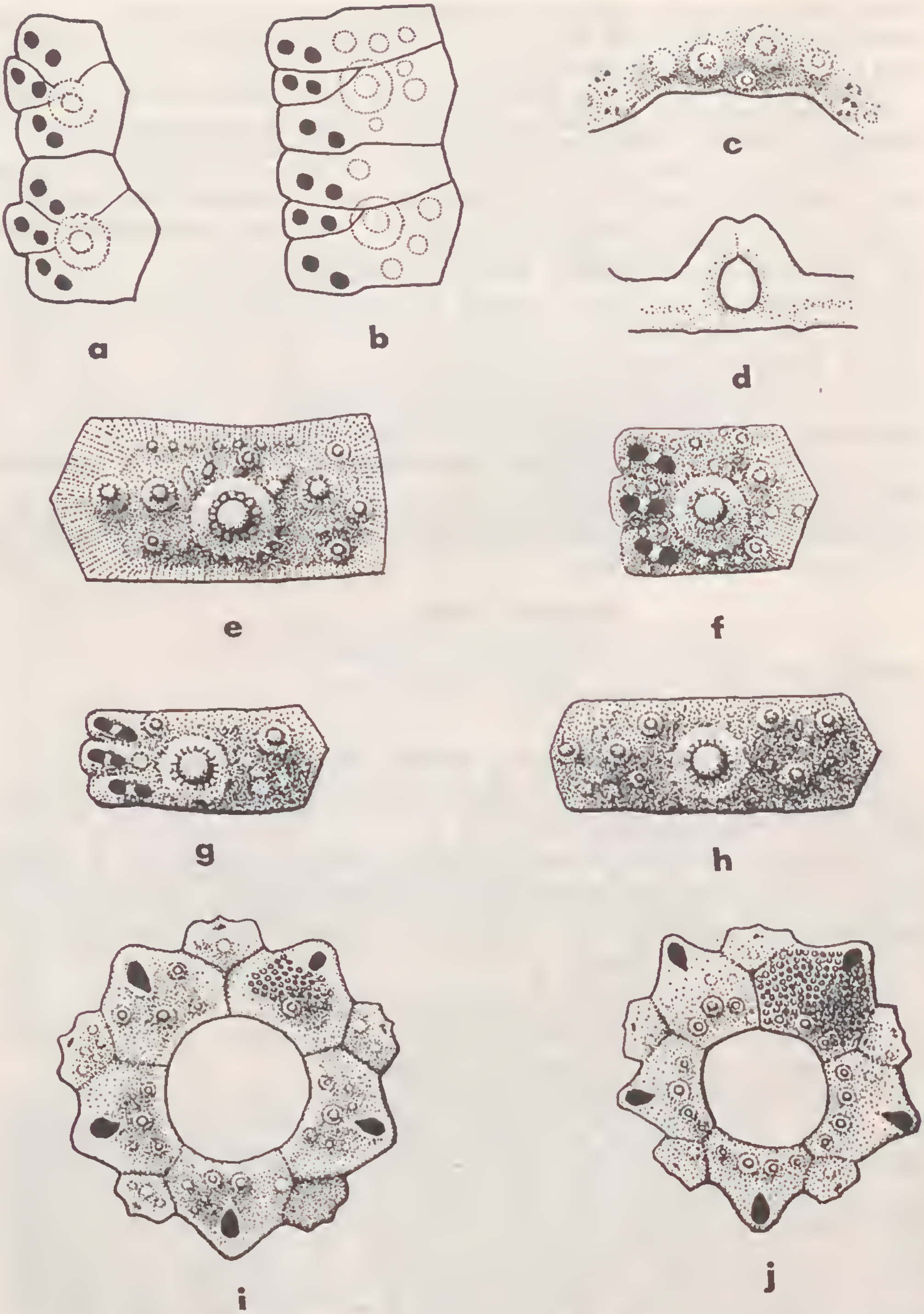

FIG. 8—a-f, i, *Tatechinus nudus* gen. et sp. nov. a, Analysis of ambital ambulacral plating of holotype (P20212), × 10. b, Adapical ambulacral plating of holotype, × 10. c, Peristomial margin showing poorly developed gill slits (P20212), × 10. d, Auricles (P19239), × 8. e, Ambital interambulacral plate of holotype, × 10. f, Ambital ambulacral plate of holotype, × 10. i, Apical system of holotype, × 6. g-h, j, *Asaphechinus tasmanensis* gen. et sp. nov. g, Ambital ambulacral plate of holotype (P19042), × 12. h, Ambital interambulacral plate of holotype, × 12. j, Apical system of holotype, × 8.

Like the ambulacra, the interambulacral plates are high, and possess small primary tubercles which form regular series toward the adradial side of each column, leaving bare the conspicuous median area of the interambulacral midzone. In the plates at and above the ambitus the ornament is confined to the middle part of each plate, so that the horizontal sutures also lie in naked areas, and a narrow naked area is also present adradially. Although this latter and the median naked area extend well below the ambitus, the horizontal areas become narrower toward, and disappear at the ambitus. Enlarged secondary tubercles tend to form horizontal series on each plate below the ambitus, and the granules, often elongate, become much more closely spaced. The tubercles are strongly crenulate and the margins of their bosses may merge with irregular granules and appear finely scalloped.

Synopsis of Material: From the Tortachilla Limestone, Upper Eocene: 'Aldinga', P20212-4, P20215, P19239; AUGD17019, 17026, 17029 and twenty-six other specimens R. J. Foster Coll. From the Blanche Point Marl, Upper Eocene; 2 specimens R. J. Foster Coll.

Measurements:

No.	h.d.	v.d.	Diameter apical system	Diameter peristome	No. ambs.	No. interambs.
AUGD17026	23·0 mm	13·5 mm	7·5 mm	*c* 8·0 mm	13(14)	15(16)
P20212	22·0	14·5	6·5	7·5	12(13)	12(13)
AUGD17029	22·0	14·0	6·0	7·5	12(13)	14
P20214	16·0	8·5	—	6·0	11	11
P19239	15·0	9·5	—	6·0	12	11(12)

Remarks: There can be little doubt that Tate (*loc. cit.*) was referring to this species when he wrote concerning '*Psammechinus Woodsi*'. 'The species is represented in the Aldinga Cliffs by the *humilior* form . . . in which the secondary granulation is almost obliterated'.

Radiolus sp. indet.

(Pl. 5, fig. 11)

A group of diadematacoid radioles (P19841-54), from the 'Murray River Cliffs, Wongulla to Mannum', probably belong to one or other of the temnopleurid species described above, for their acetabula are strongly crenulate. They are comparatively long and tapering with oblique and expanded milled rings and short bases marked by longitudinal furrows continuous with the crenulations. They could belong to either *Asaphechinus murrayensi* or *A. princeps*, forms from the same horizon with strongly crenulate tubercles.

Two similar radioles (P19974-5) are also in the collection labelled as coming from the 'lower beds, Morgan'.

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Explanation of Plates

Plate 3

Figures × 5 unless otherwise stated.

Fig. 1-9—*Cryptechinus humilior* (Bittner). (1) Superambital view of ambulacrum of neotype P17966; (2) Apical system of large specimen P17969; (3) Apical system of highly sculptured specimen AUGD17016; 'Murray River Cliffs'; (4) Superambital view of P17968, a poorly sculptured test, showing granular ridges parallel to sutures along the interambulacral midzone; (5) Superambital view of P17967; (6) Oblique view of perignathic girdle P17971, × 2; (7) Oblique view of perignathic girdle F17970, × 2; (8) Superambital view of highly sculptured specimen AUGD17016, 'Murray River Cliffs'; (9) Smallest available specimen P17964. All except AUGD-17016 from 'Morgan', Batesfordian or Balcombian.

Plate 4

Figures × 1 unless otherwise stated.

Fig. 1-6—*Cryptechinus humilior* (Bittner). (1) Adapical; (2) Adoral; (3) Lateral views of P17969; (4) Adapical; (5) Adoral; (6) Lateral views of neotype P17966. Specimens from 'Morgan', Batesfordian or Balcombian.

Fig. 7-9, 14-15—*Tatechinus nudus* gen. et sp. nov. (7) Adapical; (8) Adoral; (9) Lateral views of holotype P20212; (14) Ambital; (15) Subambital views of AUGD17019, × 5. Specimens from 'Aldinga', Upper Eocene.

Fig. 10-13—*Grammechinus meridionalis* sp. nov. (10) Lateral view of holotype P19211; (11) Adoral view of P20213; (12) Superambital view of P20213, × 5; (13) Superambital view of P20213, × 5. Specimens from 'Aldinga', Port Willunga Beds, Janjukian to Batesfordian.

Plate 5

Figures × 1 unless otherwise stated.

Fig. 1-4, 6-7, 12—*Asaphechinus murrayensis* gen. et sp. nov. (1) Adapical; (2) Adoral; (3) Lateral views of holotype P18172; (4) Apical system of holotype, × 5; (6) Superambital; (7) Apical system of sculptured juvenile AUGD17017, × 5; (12) Superambital view of holotype, × 5. All specimens from Mannum Formation, Longfordian.

Fig. 8-10—*Asaphechinus princeps* sp. nov. (8) Adoral; (9) Lateral views of AUGD17018; (10) Superambital view of AUGD17018, × 5; 'Mannum', Longfordian.

Fig. 11—Indeterminate diadematacoid radioles P19841-P19845, 'Wongulla to Mannum', Longfordian, × 2.

Plate 6

Figures × 1 unless otherwise stated.

Fig. 1-4, 8-12—*Asaphechinus singletoni* sp. nov. (1) Adoral; (2) Adapical; (3) Lateral views of holotype MUGD3490, 'Beaumaris', Cheltenhamian; (4) Lateral and internal views of two teeth MUGD3490C-D and upper surface of rotula MUGD-3490E, × 2; (8) Left; (9) Right pyramids MUGD3490A-B showing growth zones on the interpyramidal faces, × 2; (10) Perignathic girdle of holotype; (11) Superambital; (12) Oral view of holotype, × 5.

Fig. 5-7—*Asaphechinus tasmanensis* sp. nov. (5) Adoral view of P19043; (6) Adapical view of holotype P19042; (7) Ambital view of P19043, × 5. Specimens from 'Table Cape', Janjukian.

Plate 7

Figures × 5 unless otherwise stated.

Fig. 1-13—*Ortholophus morganensis* sp. nov. (1) Adapical; (2) Lateral; (3) Adoral views of P17998, × 1; (4) Adapical; (5) Lateral; (6) Adoral views of holotype P17997, × 1; (7) Oblique view of perignathic girdle P18002, × 2; (8) Apical system of P18000; (9) Superambital view of a small specimen P18001; (10) Apical system of holotype; (11) Superambital view of same; (12) Superambital view of P17998; (13) Superambital view of P17999. Specimens from 'Morgan', Batesfordian or Balcombian.

Fig. 14-18—*Ortholophus lineatus* (Duncan). (14) Lateral; (15) Adoral views of holotype BM GSL14078, 'Mordialloc', Cheltenhamian, × 1; (16) Ambital view of holotype; (17) Superambital view of P23981; (18) Adoral view of P23981, 'Beaumaris' Cheltenhamian. (14), (15), 16) British Museum (Nat. Hist.) photographs.

Plate 8

Figures × 5 unless otherwise stated.

Fig. 1-16—*Ortholophus woodsi* (Laube). (1) Adapical; (2) Lateral; (3) Adoral views of P18180, a low-tested form (var. *fascigar* Bittner), × 1; (4) Lateral view of P18179, × 1; (5) Super-ambital view of highly sculptured juvenile P18334; (6) Oblique view of girdle P18268, × 2; (7) Adapical view of P18178, × 1; (8) Adapical view of juvenile P18269; (9) Apical system of P18180; (10) Ambital view of P18180; (11) Superambital view of P18176; (12) Ambital view of P18586, 'Polyzoal limestone N of Bird Rock, Torquay', Longfordian; (13) Superambital view of juvenile P18331; (14) Superambital view of juvenile P18332; (15) Superambital view of juvenile P18333; (16) Ambital view of uncoated specimen P18609, showing traces of what is probably original colouration of the test, 'Pt. Danger', Batesfordian. Specimens from localities in the Longfordian Mannum Formation unless otherwise stated.

Plate 9

Figures × 5 unless otherwise stated.

Fig. 1-7, 9, 11-14—*Ortholophus venustus* sp. nov. (1) Adapical; (2) Lateral; (3) Adoral views of P20124, 'Longford', ? Longfordian, × 1; (4) Adapical; (5) Lateral; (6) Adoral views of holotype MUGD3492, 'Brock Quarry, Glencoe', Batesfordian, × 1; (7) Oblique view of girdle MUGD3493, same locality, × 2; (9) Test fragment MUGD3494, same locality, × 2; (11) Apical system of P20124, Longford; (12) Superambital view of holotype; (13) Superambital view of P18745, a specimen with sculpture transitional between *venustus* and *woodsi*, 'Mouth of Spring Creek', Longfordian; (14) Superambital view of P20124, 'Longford'.

Fig. 8, 15—*Pseudechinus* sp. cf. *P. albocinctus* (Hutton). (8) Lateral view of P18367, 'Toorloo Arm', Bairnsdalian, × 1; (15) Superambital view of same.

Fig. 10—*Ortholophus lineatus* (Duncan). Superambital view of P18431, 'Orbost', Bairnsdalian (cf. Pl. 7, fig. 17).

Plate 10

Figures × 5 unless otherwise stated.

Fig. 1-14—*Ortholophus pulchellus* (Bittner). (1) Adapical; (2) Lateral; (3) Adoral views of P17931 'Overland Corner', × 1; (4) Adapical view of P17986, × 1; (5) Adoral; (6) Adapical; (7) Lateral views of neotype, × 1; (8) Oblique view of girdle P17087 × 2; (9) Adapical view of juvenile P17980; (10) Superambital view of P17979; (11) Superambital view of P17984; (12) Superambital view of P17986;

(13) Superambital view of neotype P17983; (14) Superambital view of P17931. Specimens from 'Morgan', Batesfordian or Balcombian, unless otherwise stated.

PLATE 11

Figures × 2 unless otherwise stated.

Fig. 1-12—*Paradoxechinus novus* Laube. (1) Adapical; (2) Adoral view of P18266 (♀); (3) Adapical view of P18223 (♂); (4) Superambital view of same, × 5; (5) Lateral view of broken specimen showing girdle and plates of apical depression P18175 (♀); (6) Oblique view of apical depression P18266 (♀); (7) Adapical view of P18224 (♂); (8) Adapical; (9) Adoral views of P18267 (♂); (10) Lateral; (11) Adapical views of P18243 (♀), × 5; (12) Superambital view of P18224 (♂), × 5. Specimens from the Longfordian Mannum Formation.

Fig. 13-21—*Ortholophus bittneri* nom. nov. (13) Apical System of P20489, × 5; (14) Broken specimen showing perignathic girdle P20473; (15) Adoral; (16) Adapical; (17) Lateral view of neotype P20488, × 1; (18) Lateral; (19) Adapical views of P20489, × 1; (20) Superambital view of neotype, × 5; (21) Ambital view of P20473, × 5. Specimens from the Upper Eocene Tortachilla Limestone at Aldinga.

PLATE 12

Figures × 1 unless otherwise stated.

Fig. 1—*Paradoxechinus novus* Laube. Lateral view of holotype VNM9024.

Fig. 2—*Ortholophus woodsi* Laube. Superambital view of holotype VNM9019.

Fig. 3-4, 7—*Asaphechinus singletoni* sp. nov. (3) Lateral view of P23971; (4) Superambital view of same specimen; note granules aligned parallel to interambulacral midzone, × 5; (7) Ambital ambulacral and interambulacral plate of same, × 15. Beaumaris, Cheltenhamian.

Fig. 5—*Asaphechinus murrayensis* sp. nov. Subambital view of AUGD17021, × 5, '3 miles N. of Mannum', Longfordian.

Fig. 6—*Ortholophus lineatus* (Duncan). Superambital ornament of small specimen P23981, × 15.

PLATE 13

Figures × 15 unless otherwise stated.

Fig. 1—*Ortholophus woodsi* Laube. Ambital ornament AUGD17022, 'N. of Blanchetown', Longfordian, × 5.

Fig. 2-3, 5-7—*Ortholophus bittneri* nom. nov. Specimens chosen to show variation in sculpture. (2) UNE10565; (3) UNE10566; (5) UNE10567; (6) UNE10568; (7) UNE10569.

Fig. 4—*Asaphechinus singletoni* sp. nov. Apical system of a juvenile specimen P23969, 'Beaumaris', Cheltenhamian, × 5.

PLATE 14

Figures × 1 unless unless otherwise stated.

Fig. 1-3—*Asaphechinus princeps* sp. nov. (1) Lateral view of holotype AUGD17020, '3 miles N. of Mannum', Longfordian; (2) Enlargement of ambital ornament of holotype, × 5; (3) Peristome of holotype, × 15.

Fig. 4—*Ortholophus woodsi* (Laube). Superambital view of form with rare interambulacral midzones AUGD17023, '1½ miles N. of Nildottie', Longfordian.

Fig. 5-6—*Grammechinus meridionalis* sp. nov. (5) Adapical view of AUGD17024; (6) Adoral view of AUGD17025; Specimens from Whitton Bluff, Upper Eocene.

Fig. 7—*Tatechinus nudus* gen. et sp. nov. Apical system and adapical ambulacra AUGD17026, 'Aldinga', Upper Eocene, × 15.

PLATE 15

Figures × 5 unless otherwise stated.

Fig. 1—*Ortholophus pulchellus* (Bittner). Apical system with ocular plate 1 just insert, AUGD17027, 'Morgan', Batesfordian or Balcombian.

Fig. 2—*Asaphechinus tasmanensis* sp. nov. Ambital view of damaged specimen P23984, 'Table Cape', Janjukian.

Fig. 3—*Ortholophus woodsi* (Laube). Apical system of specimen with ocular plate I insert, AUGD17028, 'Mannum', Longfordian.

Fig. 4—*Tatechinus nudus* gen. et sp. nov. Ambital view of AUGD17029 'Aldinga', Upper Eocene, × 15.

Fig. 5—*Ortholophus woodsi* (Laube). Superambital sculpture of specimen approaching *O. pulchellus* AUGD17030, 'Mannum pumping station', Longfordian, × 15.

PLATE 16

Figures × 1 unless otherwise stated.

Fig. 1-6—*Evechinus palatus* sp. nov. (1) Adapical; (2) Adoral; (3) Lateral views of holotype P23967; (4) Superambital view of holotype, × 5; (5) Portion of adoral surface of holotype. × 5; (6) Termination of adoral ambulacrum at the margin of the peristome of holotype, 'Beaumaris', Cheltenhamian.

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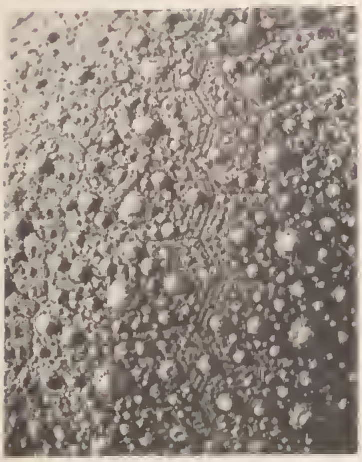

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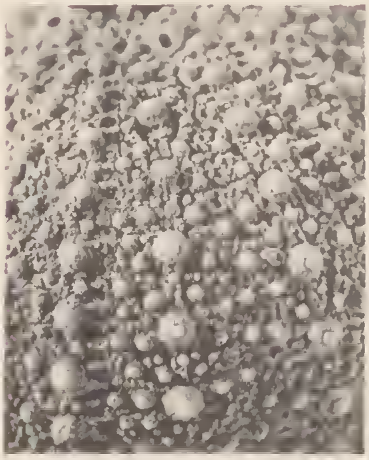

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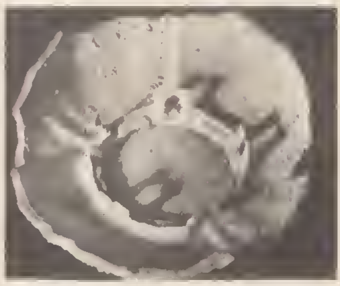

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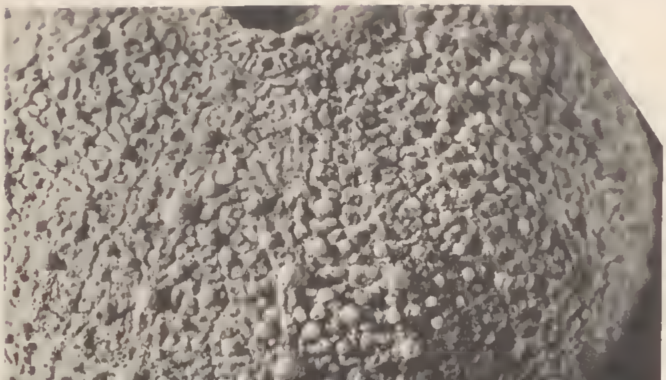

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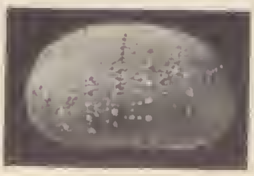
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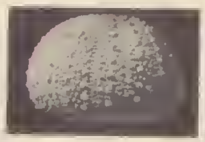
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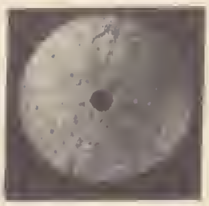
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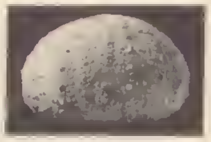
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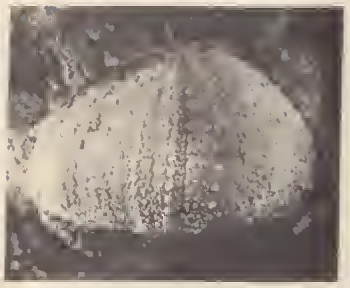
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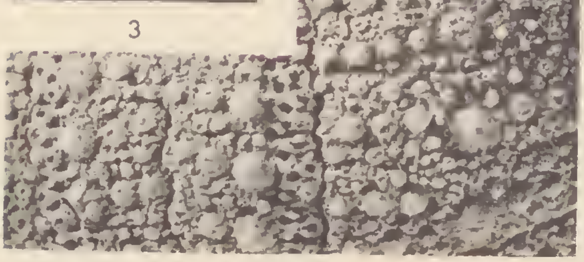
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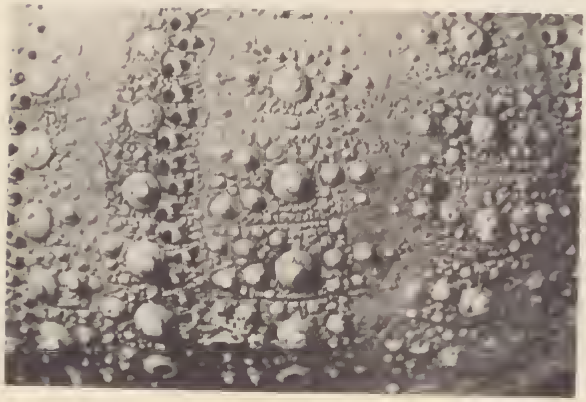
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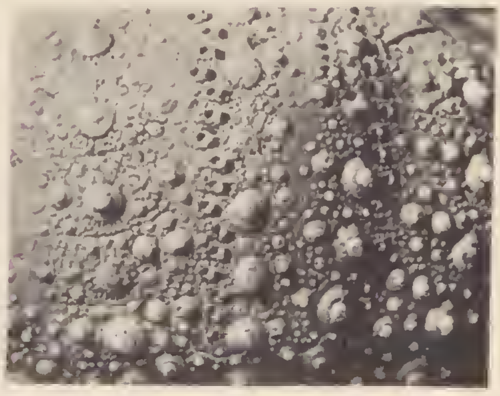
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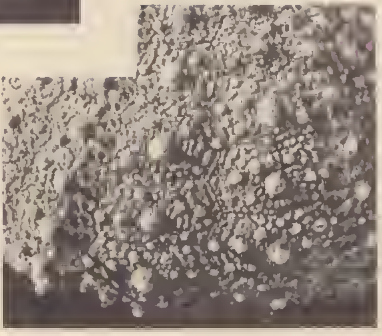

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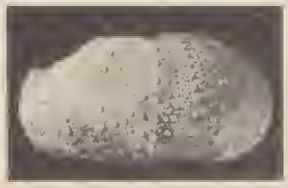

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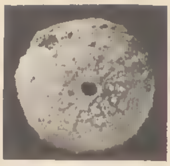
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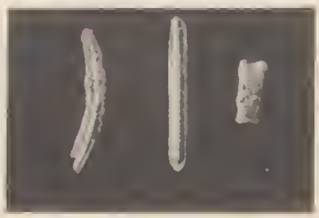
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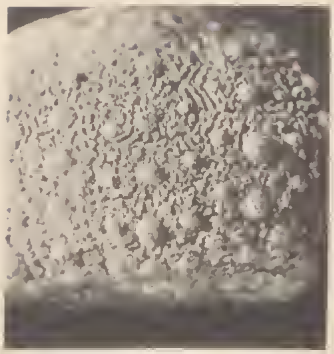
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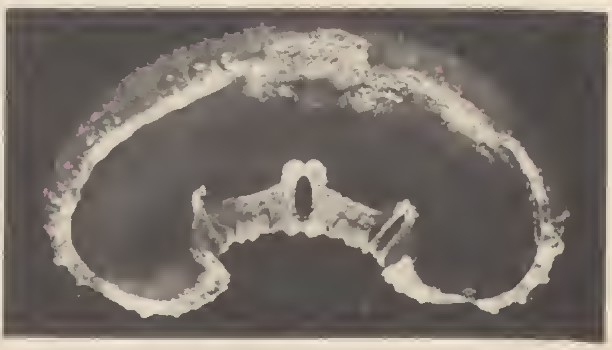
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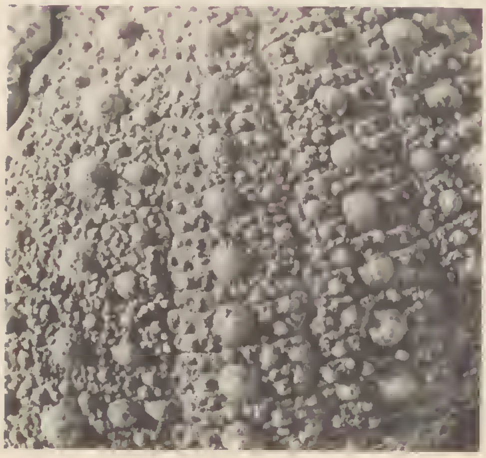
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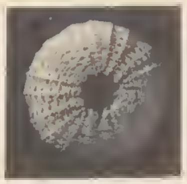
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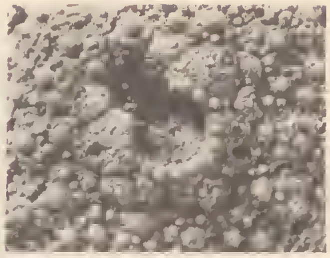
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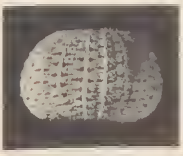
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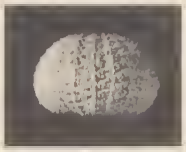
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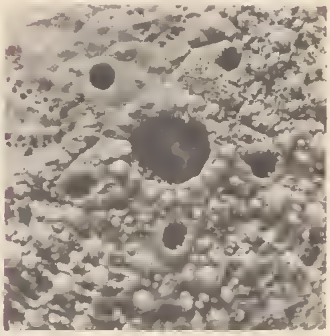
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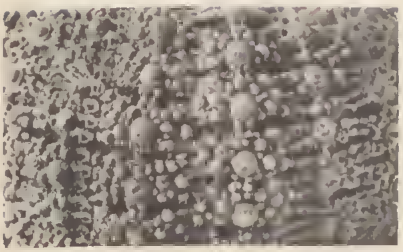
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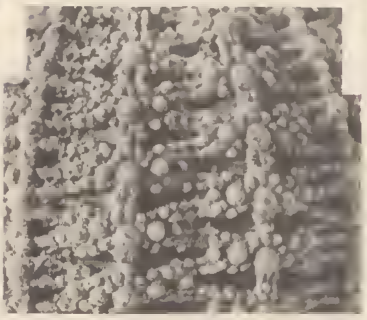
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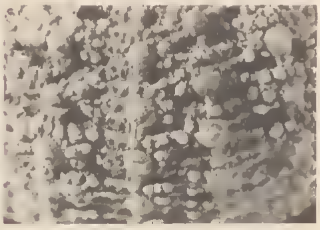
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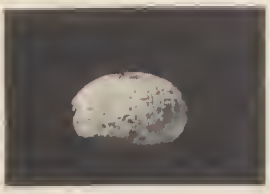
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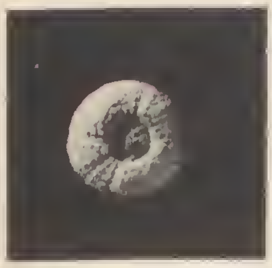
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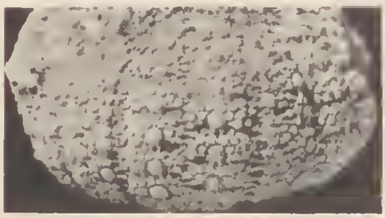
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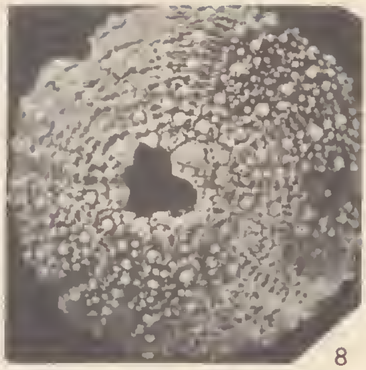
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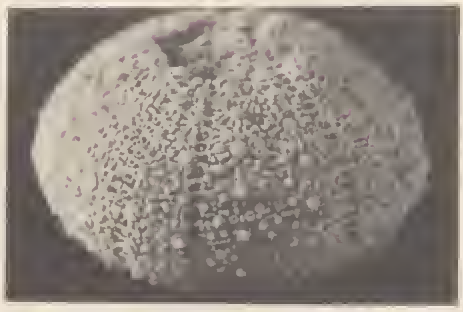
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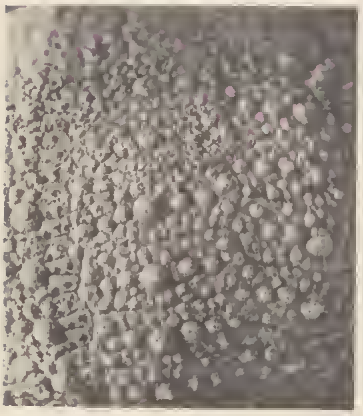
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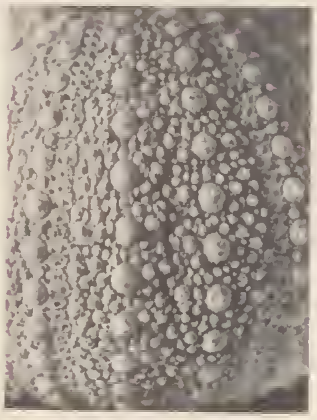
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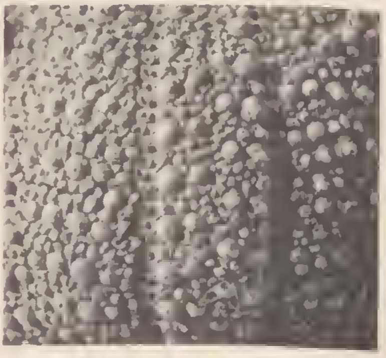
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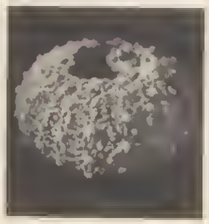
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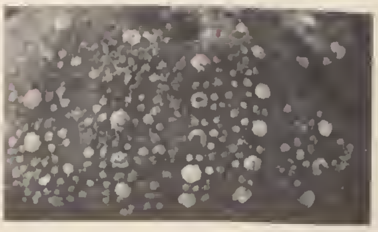
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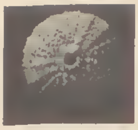
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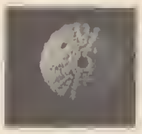
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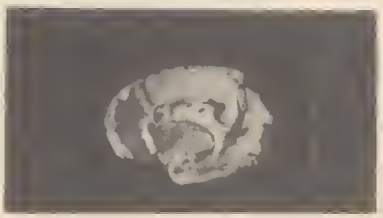
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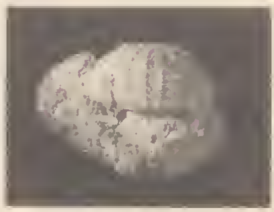
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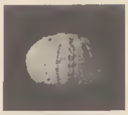
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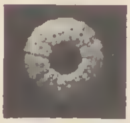
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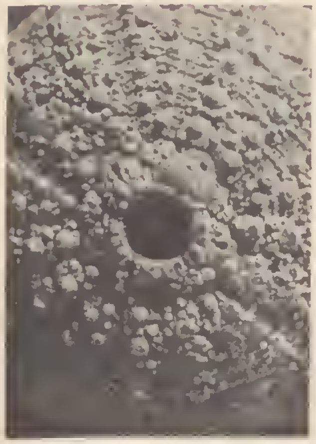
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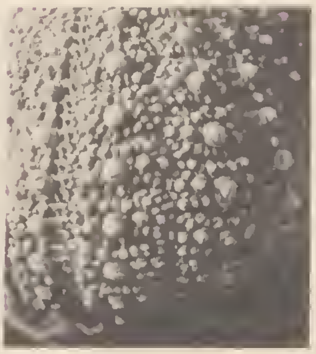
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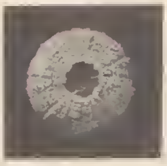
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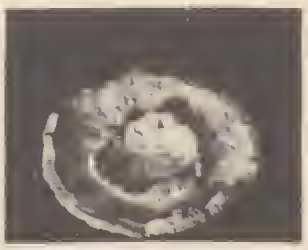
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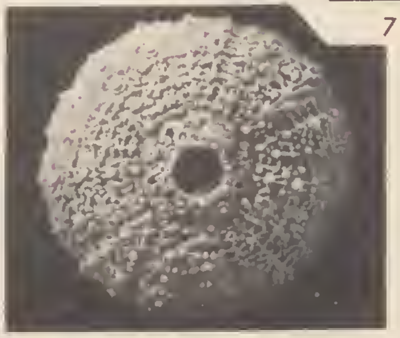
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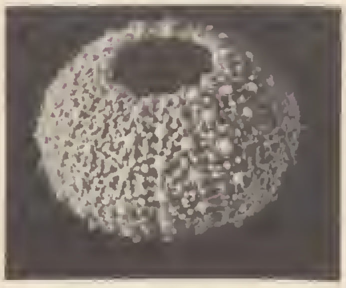
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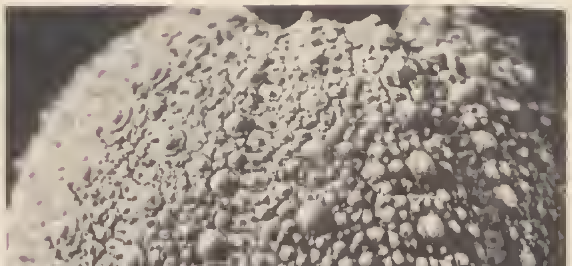
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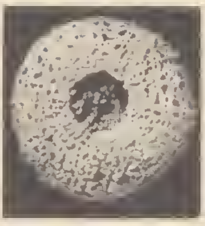
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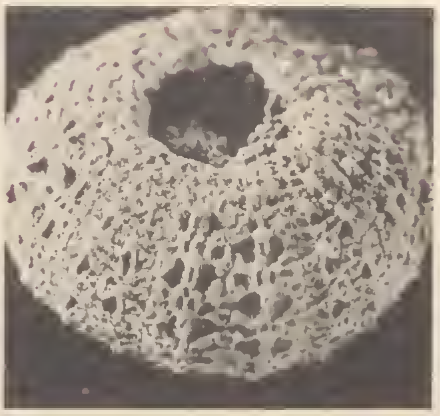
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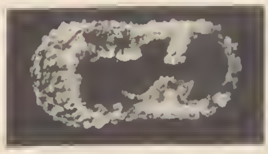
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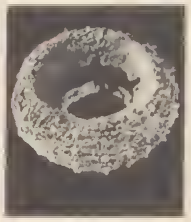
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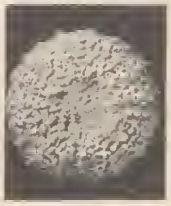
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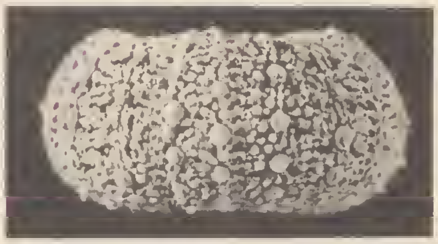
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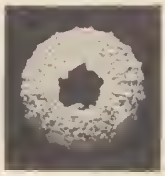
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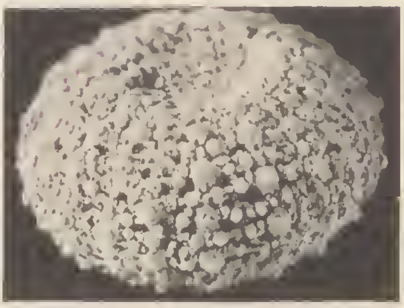
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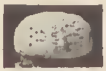
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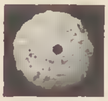
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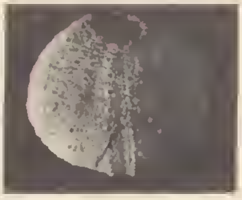

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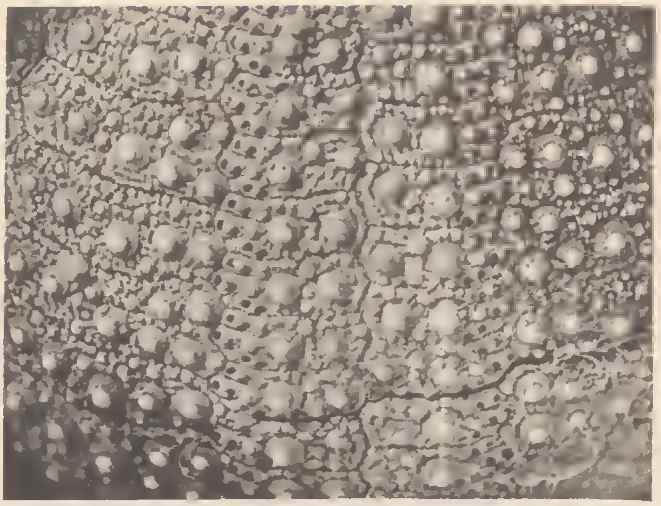

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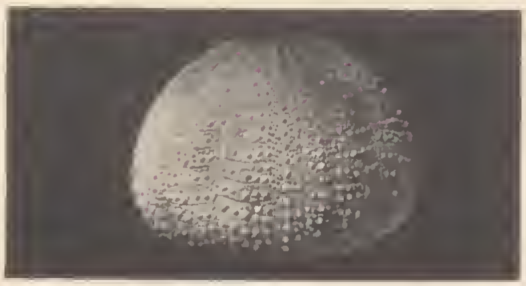

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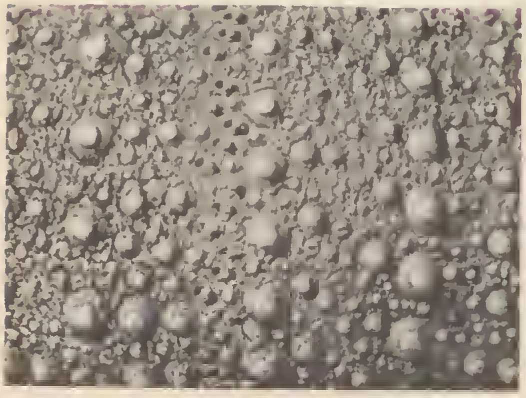

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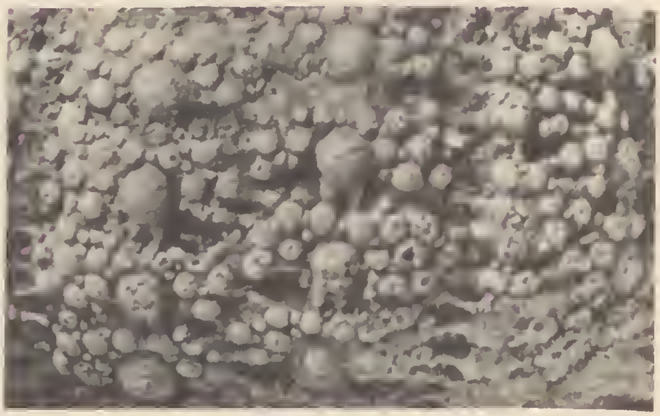

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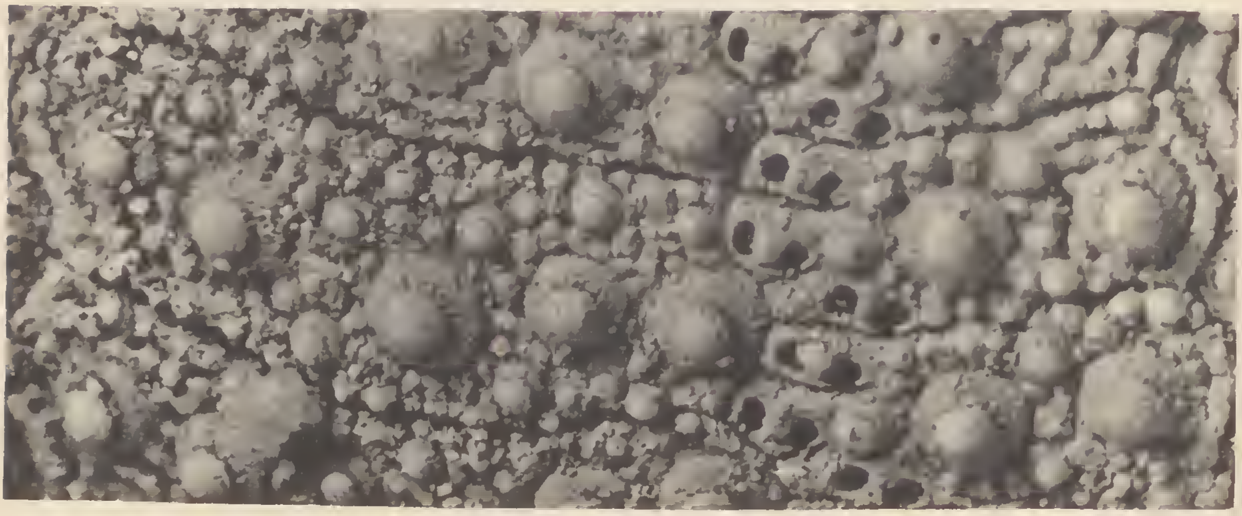

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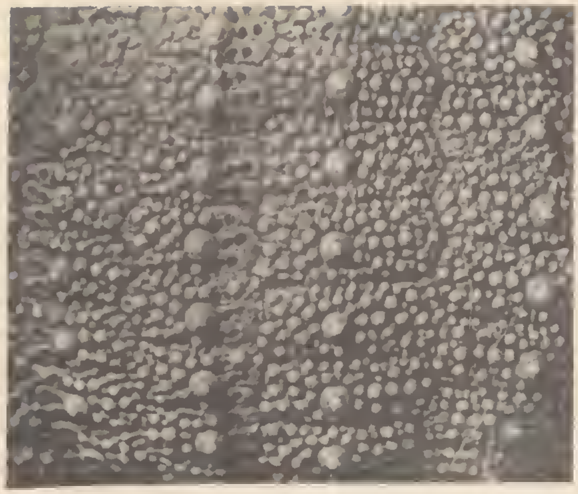

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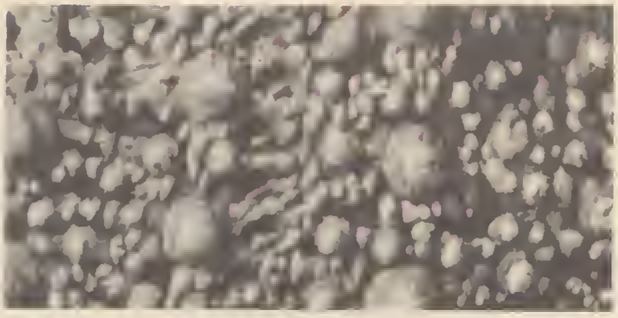

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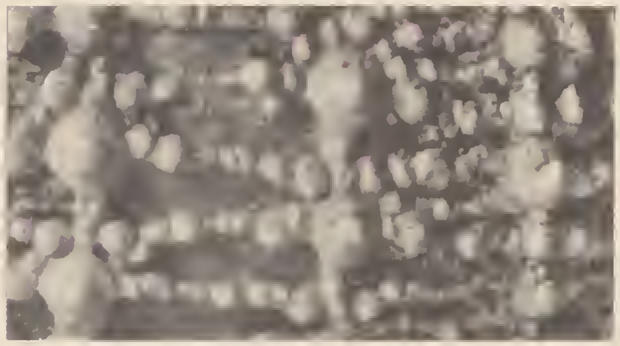

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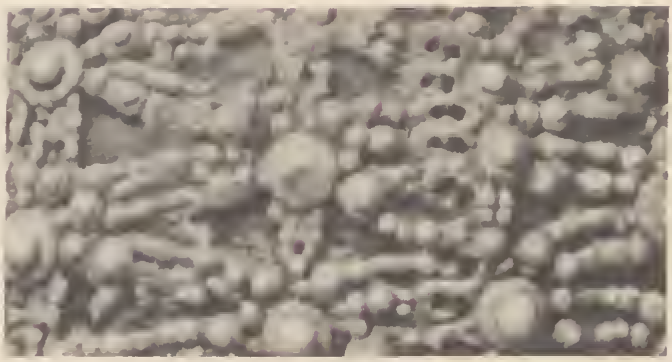

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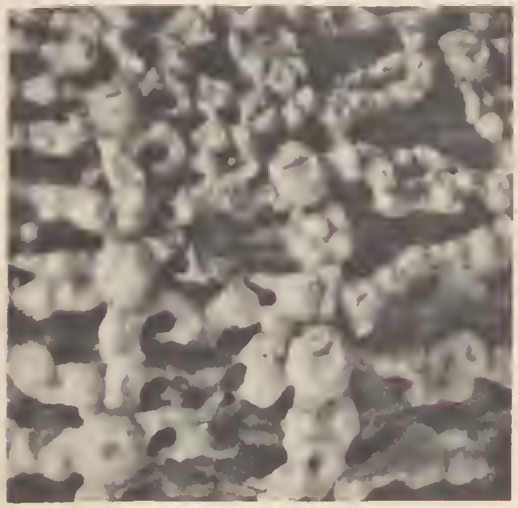

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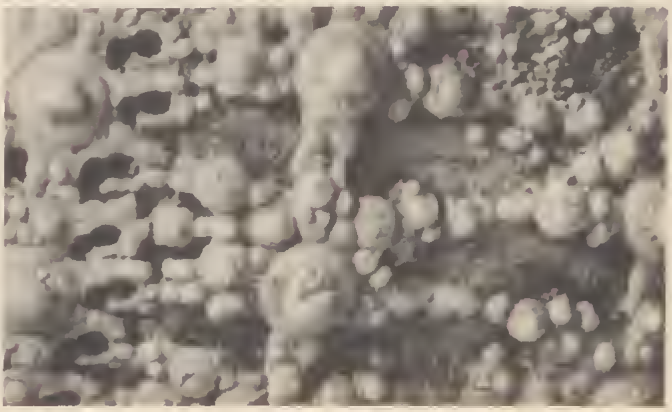

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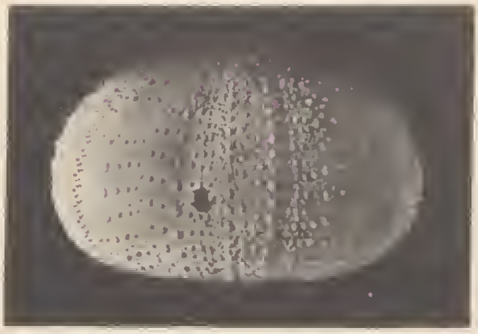

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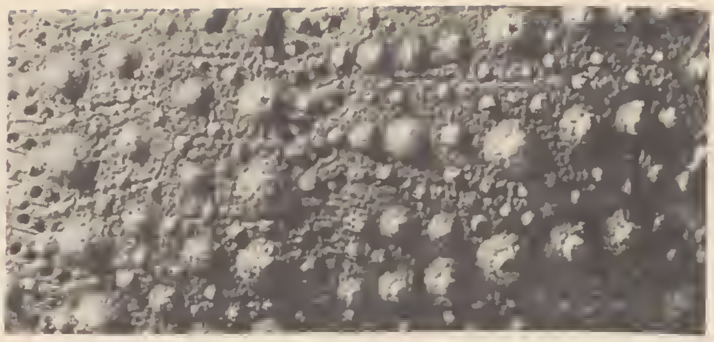

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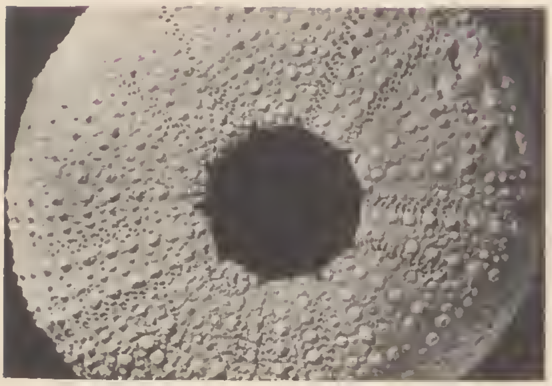

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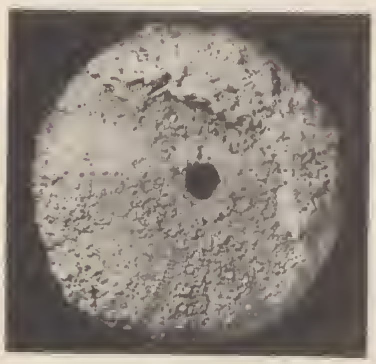

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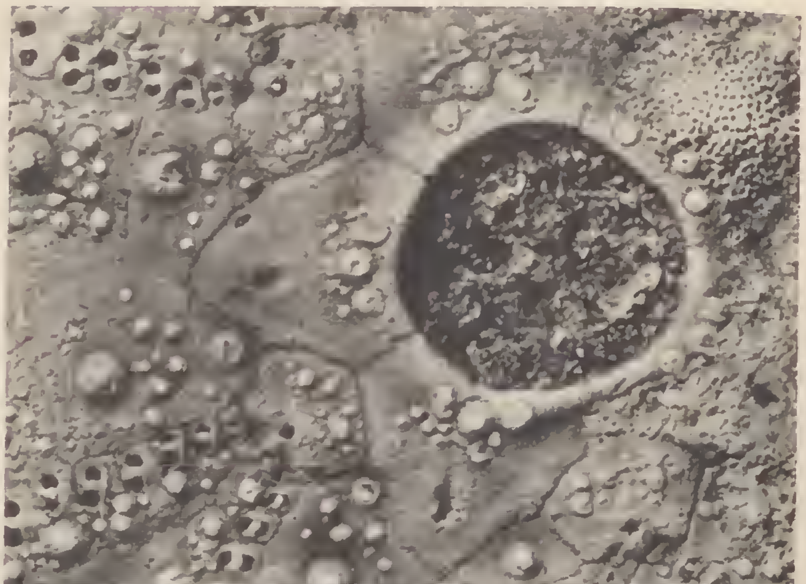

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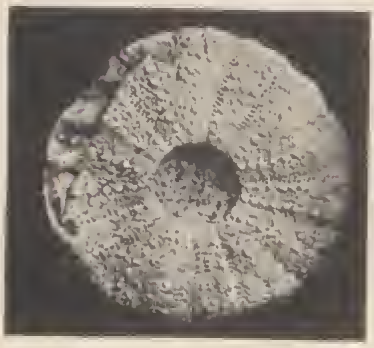

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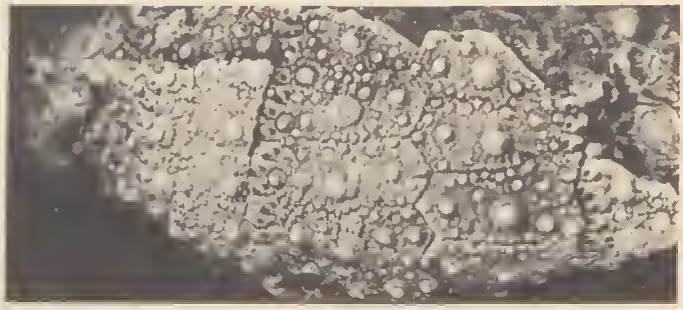

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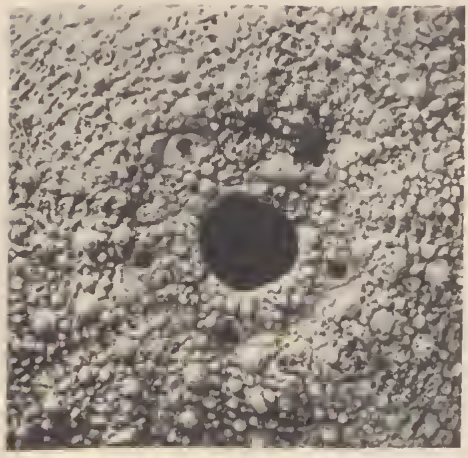

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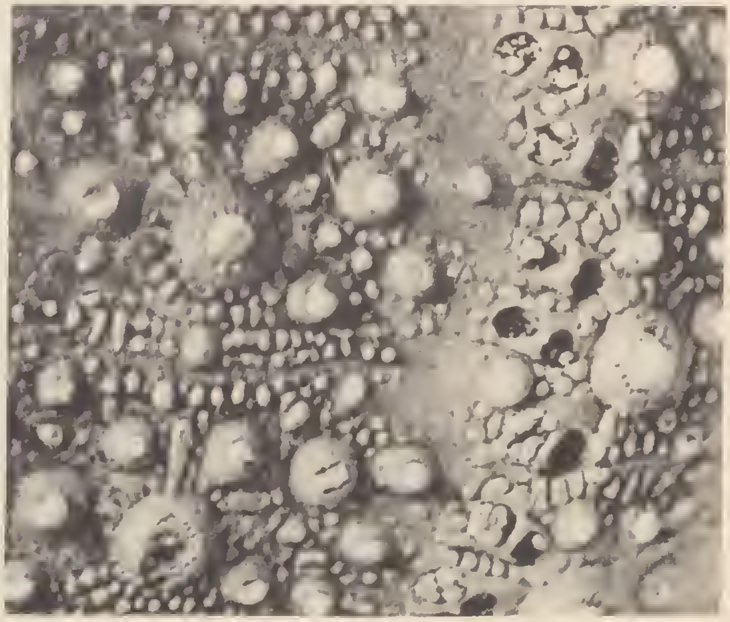

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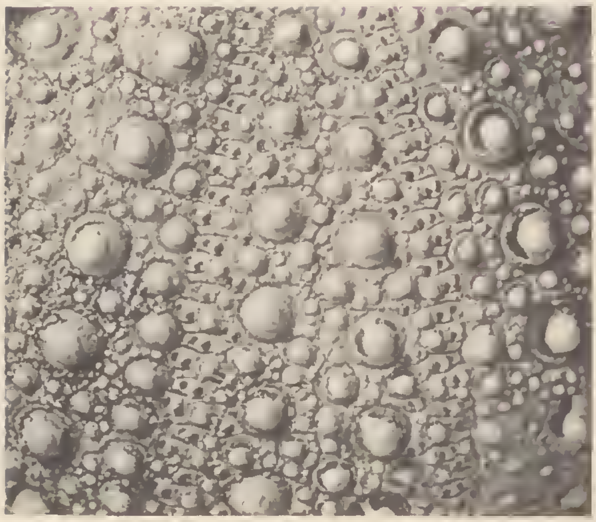

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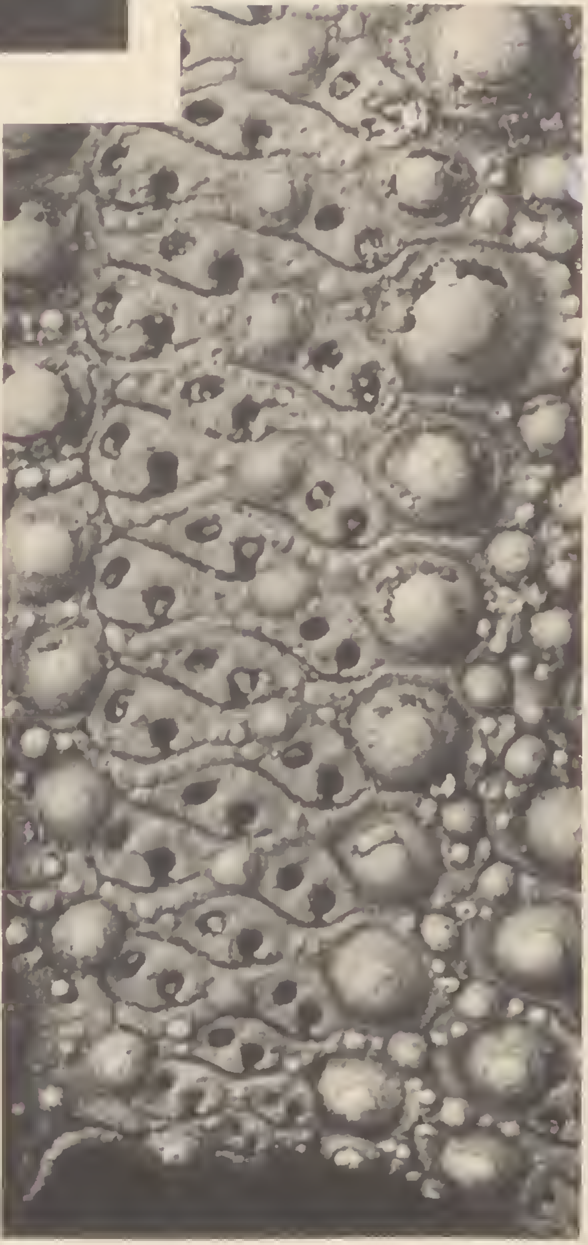

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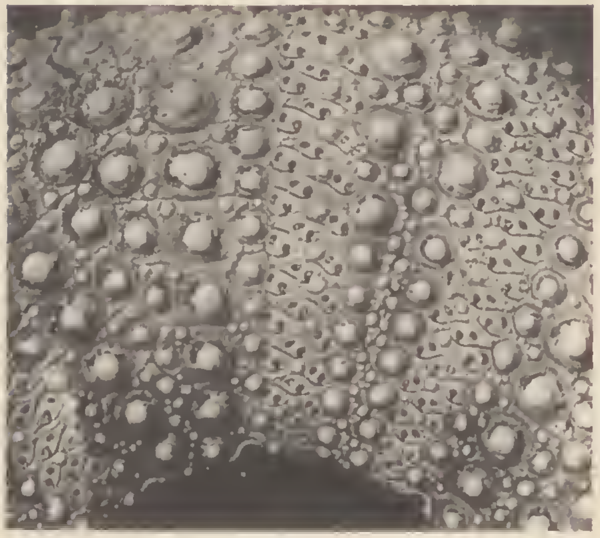

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GEOLOGY OF THE MURRINDAL RIVER—YALMY RIVER AREA EAST OF BUCHAN, VICTORIA

By KENNETH BRADLEY

Union Oil Development Corporation, P.O. Box H68, Australia Square, N.S.W. 2000

Abstract

The area E. of Buchan has extensive exposures of Snowy River Volcanics with a total thickness of about 8,000 feet, consisting of rhyodacites, pyroclastics and tuffs, with subordinate andesites, rhyolites and minor non-marine sediments. The eastern edge of the volcanics is downfaulted against tightly folded Ordovician sandstones, siltstones and cherts. The volcanics dip to the west and are overlain unconformably by fossiliferous Buchan Caves Limestone along the Murrindal R. Deposition of the limestone followed block faulting and planation of the volcanics. A block of Ordovician sediments and pre-Devonian granodiorite lies within the volcanics and represents the northern portion of a narrow belt of strong faulting extending from Nowa Nowa. Post Middle Devonian down-faulting preserved remnants of Buchan Caves Limestone of which there are five discrete enclaves within the volcanics.

Introduction and Previous Literature

An area of about 50 square miles is dealt with in this paper with a relief ranging from 300 to 2200 ft above sea level. Much of it is thickly vegetated. Portions of the area, particularly the limestone enclaves, have been studied by previous workers. The first of these was A. W. Howitt (1876) who reported briefly on the limestone of the Basin Ck and Yalmy R., the sediments at Mt McLeod, and described some of the volcanics of the area. In a later report Howitt (1882) described the basalts underlying the limestone near the confluence of the Buchan R. with the Snowy R. The age of the limestone enclaves was determined as Buchan Caves Limestones equivalent by Teichert and Talent (1958). While comparing the plutonic rocks of the Nowa Nowa area with other adjacent plutonic bodies Cochrane and Sampson (1947) found the Whisky Ck granitoid body to be a hornblende-rich acid plutonic. The area has been mapped in a general way by Gaskin (pers. comm.) in about 1950 but the sketch map produced has since been mislaid. Thus the relationships between the volcanics, limestone and the pre-Devonian rocks were still largely unknown and detailed work within the volcanics was lacking.

Ordovician

Low-grade dynamically metamorphosed sediments of Upper Ordovician age constitute the oldest rocks in the area. These outcrop extensively in the eastern portion of the area and consist of interbedded sandstones, siltstone, and cherts commonly intersected by quartz veinlets and occasionally by thick quartz veins. Lithologically similar rocks occur on Mt McLeod and in narrow belts within the granodiorite of the Whisky Ck area. Strong folding is in evidence with dips ranging to near vertical. The granodiorite is intrusive into the sediments with strong development of hornfels along the contacts. The usual contact between the Ordovician and Snowy River Volcanics is a faulted one but the existence of isolated outcrops of volcanics within the granodiorite area suggests that these are early flows unconformable to the granodiorite and hence the Ordovician. For the most part the rocks are unfossiliferous but similar strata revealed in road cuttings along New Guinea track a few miles to the north of Mt McLeod yielded poorly preserved Upper Ordovician graptolites.

Pre-Devonian

GRANODIORITE

Granodiorite outcrops over a topographically low area drained by the head waters of the Basin Ck and is almost completely surrounded by steep slopes and cliffs formed by the more resistant volcanics and Ordovician sediments. The granodiorite forms low spurs and ridges; the only feature to rise above the general level is a prominent rounded hill composed of volcanics. World Hill can be interpreted as being a remnant of one of the early flows of the Snowy River Volcanics that was extruded upon the pre-Devonian granodiorite surface; however it is also possible that this and similar outcrops of volcanics within the granodiorite owe their position to faulting. The granodiorite intrudes the Mt McLeod Ordovician sediments to the S. and appears to be bounded elsewhere by large faults. Megascopically the rock is black and white mottled, medium grained, and usually has an allotriomorphic fabric although hypidiomorphic fabrics are occasionally noted. Microscopically the essential minerals are oligoclase-andesine, potash felspar, quartz, hornblende and biotite. Twinned hornblende is the common ferromagnesian mineral in all samples, and forms up to 25% of Sample 170 while biotite is the next most common and sometimes makes up to 15% of the rock. There is probably an increase in hornblende and biotite nearer the contact with Ordovician sediments. Sample 72 is a fairly fresh rock with quartz showing undulose extinction and abundant hornblende accompanied by a few zircons in the form of short prismatic crystals with blunt pyramidal terminations. Green chlorite is also present in small amounts together with magnetite or biotite, and felspars are generally altered to some degree, often severely so, and show zoning around corroded cores. Sample 159 from the east side of Mt McLeod near the contact with the sediments has very altered and corroded silicic plagioclase which is severely sericitized and stained with hematite. Magnetite is abundant, together with shreds of biotite and cracked quartz grains. Abundant penninite occurs in Sample 71 showing an anomalous mauve to blue interference colour and is associated with fine magnetite. In some cases the rock would best be described as a quartz monzonite, as the percentage of silicic felspar of the total felspar in the rock is sometimes more than 50%. Sample 105 is probably such a rock.

Thin veins of pink felspar and quartz, often accompanied by white mica and rarely showing traces of molybdenite mineralization, are common throughout the granodiorite. The age of the granodiorite cannot be accurately fixed, apart from noting that it is post-Upper Ordovician and pre-Lower Devonian.

Lower Devonian

The Snowy River Volcanics include flows, tuffs and pyroclastic rocks of acid composition together with minor non-marine sediments. Within the area under study they are complexly faulted to such an extent that the normal sequence is obscure and their true thickness cannot be determined. Most of the individual rock units often appear to be only of limited extent and rapid changes in lithology are common. Considering the lack of adequate exposures and the restricted area under study no attempt to divide the Snowy River Volcanics into smaller units has been attempted in this paper. Generally the volcanic rocks outcropping E. of Buchan

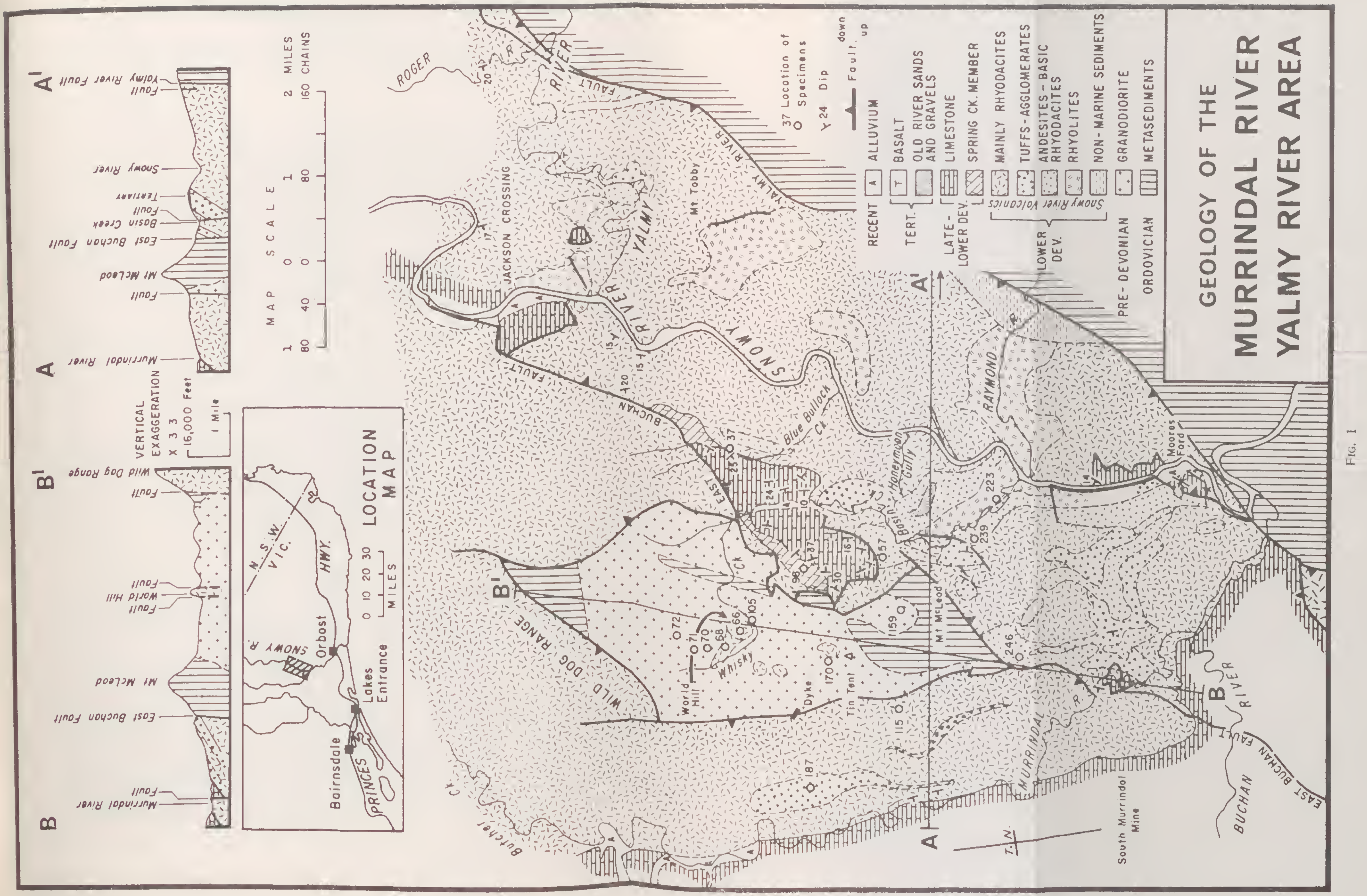
GEOLOGY OF THE
MURRINDAL RIVER
YALMY RIVER AREA
RECENT
ALLUVIUM
TERT.
BASALT
OLD RIVER SANDS AND GRAVELS
LATE-LOWER DEV.
LIMESTONE
SPRING CK. MEMBER
LOWER DEV.
Snowy River Volcanics
MAINLY RHYODACITES
TUFFS-AGGLOMERATES
ANDESITES-BASIC RHYODACITES
RHYOLITES
NON-MARINE SEDIMENTS
PRE-DEVONIAN
GRANODIORITE
ORDOVICIAN
METASEDIMENTS
37 Location of Specimens
24 Dip
Fault. down up
MAP SCALE
1 0 1 2 MILES
80 40 0 80 160 CHAINS
VERTICAL EXAGGERATION X 3.3
16,000 Feet
1 Mile
A
A'
B
B'
Murrindal River
Fault
East Buchan Fault
Mt McLeod
Basin Creek
Tertiary
Snowy River
Yalmy River Fault
World Hill
Wild Dog Range
LOCATION MAP
0 10 20 30 MILES
N.S.W.
VIC.
HWY.
SNOWY R.
Orbost
Lakes Entrance
Bairnsdale
PRINCES
ROGER
R.
RIVER
YALMY RIVER FAULT
JACKSON CROSSING
YALMY
Mt Tobby
SNOWY RIVER
BUCHAN FAULT
EAST
Blue Bullock Ck
Honeymoon Gully
Basin Ck
RAYMOND R.
Moores Ford
Mt McLeod
Whisky Ck
World Hill
Dyke
Tin Tent
WILD DOG RANGE
MURRINDAL R.
BUCHAN
EAST BUCHAN FAULT
RIVER
South Murrindal Mine
Butcher Ck
T.N.

Fig. 1

appear to be representative of the upper part of the Lower Devonian succession and indicate that the lower portion (including the Timbarra Formation) has been faulted out by movement along the Yalmy River Fault to the E. of the Snowy R. Because of the variation within even one lithologic type it is proposed to discuss these rocks under a general rock type name, regardless of relative age.

RHYODACITE

The most common lava type in the area is best described as rhyodacite. These flows generally form thick, massive, and very weather-resistant outcrops, as for example those outcropping in the Wild Dog Range, through occasionally they are only a few tens of feet thick and of only local extent as in the beds outcropping along Spooner Ck. In the hand specimen the colour of these rocks varies from dark grey through purple-brown to light salmon pink, the lighter colours being the most common. The rhyodacites are usually medium to coarsely porphyritic with a fine-grained to dense, mostly glassy ground-mass. Sample 115 from the section exposed in Shaw Ck illustrates the coarse nature of many of the rhyodacites, since it contains abundant quartz up to 0·4 cm in size which is corroded and cracked in part, together with acid plagioclase, pinkish and commonly zoned, in a glassy dark purple groundmass. Fine magnetite occurs seattered throughout the rock. Quartz phenocrysts are sometimes almost absent as in sample 66 which is a hard dense dark greenish-grey rock forming a prominent rounded outcrop known as 'World Hill'. It is possible that this is a remnant of an early flow lying on the eroded surface of granodiorite. The main constituents are fine to medium grained phenocrysts of twinned and corroded subhedral plagioclase, sericitized and rimmed with relatively unaltered albite, while smaller quartz and sanidine crystals, euhedral to subhedral, are less common and are frequently corroded by the groundmass. The groundmass is silicified and contains fine felspar and sericite grains. Mica flakes in perfect hexagons up to 0·1 cm diameter are common in this rock and are accompanied by rock fragments consisting of rhyodacite with a few sedimentary rock chips in a purplish-brown groundmass. Mica rhyodacites can usually be found in most parts of the succession and particularly in the rocks exposed in Shaw Ck where there are several flows of this type. Flow structures are sometimes discernible in thin sections but are more commonly absent.

RHYOLITE

Lavas referred to here as rhyolites outcrop extensively in the E. and SE. portion of the area where they typically form high cliffs along the banks of the Snowy R. and its tributaries. The rhyolite flow outcropping along the east bank of the lower Basin Ck is about 85 ft thick and the flows to the E. of the Snowy R. are probably much thicker than this and are in the order of a few hundred feet thick. Flow structure is usually very well developed and is typically shown in Sample 223 from an outcrop near the junction of the Basin Ck with the Snowy R. where the eutaxitic nature of the rock is shown by the alternating thin bands of differing colours varying from light brown through purple to dark grey. Weathering reduces the bulk of these bands to a soft, pale brown material with grey resistant bands, thus enhancing the flow structure, and occasional spherulites can usually be seen alternating with bands containing scattered aggregates of fine quartz, felspar, and hematite. Occasionally quartz phenocrysts are present, as in Sample 227, which are mainly anhedral and make up about 30% of the rock. Common opal is often found as fillings in fractures within these rocks.

ANDESITE

Most of the flows mapped as 'andesite' would be better described as having andesitic tendencies; some are true dacites but due to their distinctive appearance they have been grouped under this term for convenience. Andesitic rocks are almost entirely restricted to the E. of the Murrindal South mine, S. of Mt McLeod and W. of the Snowy R., and it is probable that these rocks are in a zone near the top of the Snowy River Volcanics sequence. Howitt (1882) described rocks underlying the limestone at Moore's Ford on the Snowy R. in the Murrindal South Mine area and along the lower Buchan and Back Ck as 'diabase porphyritic'. There is a belt of andesitic flows commencing at the junction of the Basin and Basin Ridge Roads and continuing S. towards the Murrindal South Mine along the ridge above the road. The andesite overlies a tuffaceous and agglomeratic sequence. Similar rocks occur S. of the Basin Ck bridge and continue down the W. bank of the creek towards the Snowy R. with rhyolite outcropping on the E. side. At the Snowy R. the same relationship exists along the W. bank for at least ½ mile. Between the Basin Road and the southern edge of the Basin limestone, andesitic rocks predominate and may extend farther across the road and around the head of Honeymoon Gully towards the Snowy R. The degree of weathering in these rocks is usually most severe and rarely is fresh rock exposed. Quartz is often present in appreciable amount as in Sample 55, which has abundant zoned and twinned plagioclase laths, magnetite, and small green hornblende crystals in a felted groundmass of felspar laths. In the hand specimen these rocks are often fine grained, dark rocks, but porphyritic varieties are common and phenocrysts of hornblende, plagioclase, or pyroxene are often noted. Hornblende occurs as phenocrysts in Sample 246 from outcrops along the Basin Road near the junction with the Basin Ridge Road. Plagioclase is the dominant phenocryst in Sample 221 of an outcrop at the head of Honeymoon Gully, lying in a groundmass of squat felspars and iron oxide masses. Sample 239 has pyroxene phenocrysts, largely altered, in a groundmass composed of small quartz crystals and plagioclase laths. Green chloritic material is associated with magnetite in much of this groundmass.

TUFFS

Pyroclastic rocks of acid composition make up an appreciable amount of the Snowy River Volcanics. They can rarely be traced any distance in the field since they often closely resemble flows, due to their high susceptibility to alteration. Tuff beds were occasionally used in determining structure and to indicate the strike of some restricted areas of volcanics, particularly in the western portion of the area. The beds frequently show severe silicification, making the distinction between them and flows very difficult, especially when they are not more massive. It is probable that many of the rocks referred to as rhyodacites were originally tuffs but have now undergone such alteration as to make their origin uncertain; however, undoubted tuff beds are known in many parts of the area and contain tuff balls in a few localities. Sample 187 from an outcrop of light creamish indurated tuff north of Shaw Ck contains occasional tuff balls ½ to 1 cm in diameter, and the brecciated silicified tuff near the Basin Ck bridge has flattened tuff balls in some abundance. They have also been noted in the section exposed along Running Ck where tuff and ash beds alternate with rhyodacite flows. The colour of the tuffs varies from green through pale green and light browns to grey; they are usually fine to medium grained and friable to indurated. In the section exposed along a track about 1½ miles N. of Shaw Ck a tuffaceous sequence of nearly 200 ft thickness contains green and cream tuff beds with some tuffaceous sandstone intercala-

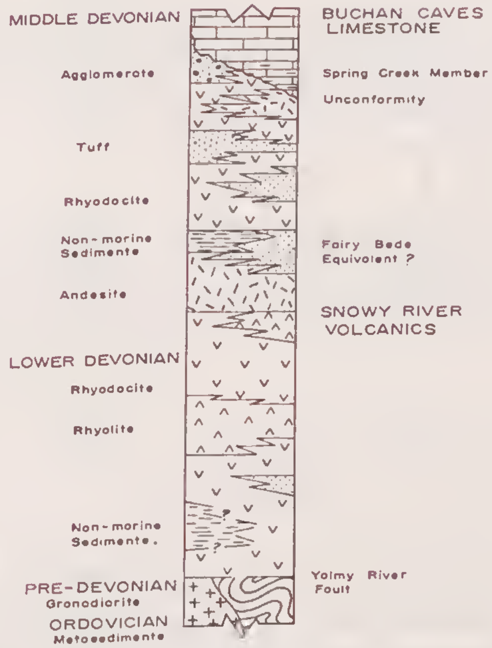

FIGURE 2

STRATIGRAPHIC COLUMN.

FIG. 2

tions. A few tuff balls have been noted in these beds and the sandstone probably indicates some water sorting. This is evident also in other sections, as in the tuffaceous beds immediately underlying the limestone in the Basin Ck area. In the Basin Ck sections the tuffs are generally silicified but clearly show evidence of reworking as in Sample 37. Exposures in the Blue Bullock Ck from which Sample 37 was taken show fine banding and complex current bedding and consist dominantly of chert which is present in fine bands and as lens-like masses in ash beds. Siliceous solutions derived from the volcanics are probably responsible for the cherty nature of the beds. Coarser grained varieties sometimes occur as in the section exposed in Spooner Ck illustrated by Sample 98 from this locality. This has coarse fragments of quartz, felspar and rock pieces together with mica, fragments of pumice and brown glass in a fine matrix of quartz, mica, felspar and glass. S. of the Basin limestone along the Basin Road there are outcrops of massive poorly exposured, unstratified tuff beds interbedded with rhyodacite flows. These are dark purplish rocks with some quartz up to 4 mm in diameter; felspar is fairly common up to 2 mm. Rock fragments are present usually about 5 mm in diameter and green chloritic material forms veinlets throughout the mass. Agglomeratic phases were noted in places.

SEDIMENTS

Narrow and restricted belts of sediments intercalated within the volcanics occur in a number of isolated areas. About ½ mile SW. of the junction of the Roger and Yalmy Rivers poorly exposed sediments have been revealed along a jeep track, but include yellow-brown and chocolate-brown micaceous siltstones interbedded with grey-green, and grey and orange, tuff beds. Blue-green chloritic material is common in the tuffs as streaks, and occasional quartz grains can be seen in the hand specimen. The sediments overlie a weathered outcrop of andesitic rhyodacite, and are in turn overlain by a hard purplish rhyodacite, medium grained and containing abundant quartz phenocrysts and felspar laths. A similar sequence of sediments can be seen on the track into 'Dargan's' on the east side of the Snowy R. immediately N. of the small limestone enclave, and again this outcrop is bounded on all sides by volcanics but its position in the section is not clear. The very poor exposures in this area make an estimate of the thickness difficult but there may be about 100 ft of section present. Dips within the sediments appear to be in the order of 80°. These beds may be equivalent to the Fairy Beds of Talent (1958). Other sedimentary strata believed to be of Lower Devonian age outcrop on the Raymond R. These are caught against the Yalmy Ck fault but have not been the subject of any detailed investigation at this time.

Middle Devonian

BUCHAN CAVES LIMESTONE

There are five discrete areas of limestone, all equivalent to the Buchan Caves Limestone in the mapped area. The largest of these outcrops on Basin Ck where an estimated 350+ ft of fossiliferous meso-grained limestone and dolomitic limestone is exposed including about 50± ft of Spring Creek Member equivalent.

On the NE. side of the outcrop the limestone overlies agglomerates and lavas of Snowy River Volcanics. The Spring Creek Member extends up the dip slope formed by the volcanics as a thin cover from Blue Bullock Ck and northwards towards Running Ck. The beds include interbedded tuffs, agglomerate, dolomitic limestones and sandy tuffs. Some of the finer clastics are cherty with occasional siliceous lenses and are well indurated. A band of limestone a few feet thick containing abundant *Aulopora* cf. *conglomerata* and *Syringopora flaccida*, outcrops in Blue Bullock Ck. A similar assemblage has been noted to occur within the Spring Creek Member in the Buchan Caves Reserve by Talent (1958). On the NW. side of the limestone similar beds outcrop in the northern arm of Spooners Ck. The sequence includes tuffs, mudstones, minor rhyodacite flows and a distinctive red and white fossiliferous band of jasper with manganiferous partings. Within the band the fossils are replaced by both jasper and chalcedony, the dominant tendency being infilling by chalcedony followed by replacement of matrix by jasper. These beds exhibit contradictory dips and are probably faulted. Farther W. the section becomes more volcanic until it is terminated by a fault breccia composed of quartzite fragments which borders the granodiorite. Within limestone between the Basin and Blue Bullock Creeks the following were collected and subsequently identified by Dr J. A. Talent:

Spinella buchanensis Talent
Chalcidophyllum recessum (Hill)
Favosites bryani Jones
Disphyllum? sp.
Buchanathyris?

Small gastropods cf. *Anematina*
Small brachiopod indet.
Algal pisoliths.

The above fauna is characteristic of the middle portion of Buchan Caves Limestone. Other limestone and dolomitic limestone bodies include those at Jackson's Crossing, Moore's Ford, the South Murrindal Mine area and a small patch on the lower Yalmy R. All of these bodies are Buchan Caves Limestone equivalents and owe their preservation to faulting.

Tertiary

BASALT

Basaltic dykes intrude Devonian sediments at Murrindal and other localities towards Buchan and have been considered as Tertiary by Teichert and Talent (1958). A dyke of probable similar age intrudes granodiorite in a road cut on the Basin Ridge Road just N. of Mt McLeod. A small area of basalt occurs on the S. bank of the Yalmy R., N. of Mt Tabby.

SANDS AND GRAVELS

Three areas of sands and gravels have been mapped S. of the Basin road. The deposits consist of yellowish to light greyish, poorly consolidated, poorly bedded clayish sands and gravels. The deposit south of the road junction of the Basin and Basin Ridge Roads is finer than the others and consists of yellow-orange sand with some iron banding and lies about 750 ft above sea level. At the head of Honeymoon Gully the gravel deposit at the top of the hill includes small boulders and large lumps of fossil wood. The pebbles consist of quartz, quartzite and some sandstone, usually well rounded and averaging about 2-3 inches diameter. The base of this deposit is about 680 ft above sea level. A small area of gravel occurs near the Dargan farm above Moore's Crossing, the base of which lies at approximately 830 ft above sea level.

The Buchan Caves Limestone—Snowy River Volcanics Contact

The nature of the contact between the Snowy River Volcanics and the Buchan Caves Limestone was previously considered by Teichert and Talent (1958) as being essentially conformable. However later mapping by Fletcher (1963) on the western side of the Buchan Basin seemed to indicate that a disconformity existed. Later work convinced Talent (pers. comm.) that a considerable time gap separated the cessation of volcanism from the initiation of true carbonate sedimentation. Where the contact can be seen along the Murrindal R. and on the eastern edge of the limestone on the Basin Ck, the dips of the volcanics and the limestone appear similar but the underlying volcanics are definitely not contemporaneous along the contact. At Mt Waterson, near Bindi, Buchan Group sediments can be seen resting upon the planated surface of fault blocks consisting of Snowy River Volcanics and Cowombat Group (Talent 1965). This type of relationship appears to exist in the Buchan area and is illustrated by considering the narrow belt of complexly faulted Ordovician sediments, pre-Devonian granodiorite, and Snowy River Volcanics which extends from Nowa Nowa through Mt McLeod towards Butchers Ck. This belt is controlled by faults with throws of considerable magnitude. However in the area immediately W. of the lower Buchan R. the belt is interrupted by a cover of Buchan Group sediments which exhibit far less deformation than would have been expected had they taken part in the main block faulting. The southern portion of the Buchan group in this area is controlled by tear faulting which, accompanied by thrust faulting largely along pre-existing fractures, tends to explain satisfactorily the deformation present in the middle Devonian sediments. Thus it appears that the Buchan Group was deposited over the planated blocks of Snowy River Volcanics. However some evidence is available in the belt of the Spring Creek Member on the NW. side of The Basin to indicate that limited volcanism continued for a short time prior to the true carbonate sedimentation. Interbedded volcanics, reworked volcanics and lime impregnated sediments precede the limestone sedimentation in a number of localities throughout that area, and by implication elsewhere.

Structure

Prior to Buchan Group sedimentation, movement occurred along the Nowa Nowa-Butchers Ck fault zone and on the Yalmy River Fault. Movement on the Yalmy River Fault is of considerable magnitude, indicated by the wide zone of brecciation seen in the Snowy R. immediately upstream from its junction with the Buchan R. The absence of Timbarra formation in the area can be explained by movement on this Fault. The Nowa Nowa-Butchers Ck fault zone probably represents an elongate block-faulted portion of the basement paralleling the Yalmy River Fault, separated from it by more stable blocks now occupied by Snowy River Volcanics. Movements between the blocks within this zone are more spectacular than movements between blocks to the E. and W. In post Middle Devonian times renewed, dominantly compressive movements along the Fault including the East Buchan Fault produced a pattern responsible for the enclaves of Buchan Caves Limestone as we see them now. The present limits and irregular shapes of the limestone within the volcanics are largely due to tear faulting, intimately connected with the larger scale faulting. The Buchan Thrust Fault (Talent 1958) occurred at this time; it merges northwards with the faults bounding the McLeod block, faults splaying off and merging in a pattern whose broadest outlines only can be deciphered from surface mapping. Movement on the Yalmy River Fault was sufficient to allow erosion to remove all signs of Snowy River Volcanics from the high east block so that the Fault provides the present day eastern limit for the volcanics against the Ordovician sediments. That some additional down faulting of the block between the Yalmy R. and East Buchan Fault occurred in Tertiary times may be indicated by the preservation of Tertiary sediments and basalt upon this block. The Snowy R. also appears to flow upon the block, which may indicate that this area was lowered fairly recently.

Most of the structure within the volcanics appears to be simple with a predominance of westerly dips. In Shaw Ck the volcanics dip at about 22°W. beneath the limestone along the Murrindal R. E. and S. of Jackson's Crossing the dips are in the order of 15-17°W. Near the large faults such as the East Buchan Fault, dips up to 60° have been noted and are variable in direction. Many less pronounced zones of shearing and faulting (affecting the volcanics) other than those already mentioned have been noted, but their trends and relative importance are impossible to estimate, particularly S. of the Mt McLeod block.

Summary

By implication elsewhere, the Ordovician Sediments of the Murrindal-Yalmy R. area were subjected to deformation (Bowning Orogeny) and intrusion by granodiorite immediately prior to the beginning of the Devonian.

Following the de-roofing of the granodiorite batholith a thick sequence of non-marine clastics (Timbarra Formation) was deposited and subsequently buried beneath a thicker sequence of acid extrusives and pyroclastics with minor intercalations of non-marine sediments (Snowy River Volcanics).

The Ordovician sediments and Pre-Devonian granodiorite together with the Snowy River Volcanics were then block faulted and planated before the area subsequently sank and allowed the entry of a transgressive sea resulting in carbonate deposition (Buchan Caves Limestone) during the Middle Devonian.

Movement on the faults active immediately prior to the Middle Devonian deposition were of considerable magnitude and were sufficient to fault out the Timbarra Formation in the area E. of Buchan.

In post Middle Devonian times renewed dominantly compressive movements occurred along the older fault zones resulting in the present limestone enclaves and allowing erosion to remove all signs of Snowy River Volcanics from the high block E. of the Yalmy River Fault.

The area was lowered during Tertiary times and received terrestrial sediments before further slight structural adjustments took place producing a low block upon which the Snowy R. now flows.

Acknowledgements

This paper is taken from a thesis intended for submission for the Fellowship Diploma of Geology in the Royal Melbourne Institute of Technology.

The useful advice and encouragement during the preparation of this paper afforded by Dr J. A. Talent of the Geological Survey of Victoria is gratefully acknowledged. Acknowledgement is also made to the Drawing Office, Department of Mines, Victoria for drafting the map.

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17

SILURIAN CONODONTS FROM THE DIRK HARTOG FORMATION, WESTERN AUSTRALIA

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Abstract

Conodont elements from the subsurface Dirk Hartog Formation, W.A., recovered by Glenister and Glenister (1957) are described and figured. The European ranges of these elements suggest a mid and late Ludlovian age for the upper part of the formation.

I. Introduction

The conodont elements described in this paper afforded the first record of Silurian conodonts in Australia (Glenister and Glenister 1957). They were recovered from the upper part of a carbonate unit intersected between depths of 2183 ft and 4608 ft in WAPET'S Dirk Hartog No. 17B test bore on Dirk Hartog Island, Western Australia (25°51′58″S., 113°04′40·5″E.). This unit was named the Dirk Hartog Limestone by McWhae *et al.* (1958, p. 31).

Glenister and Glenister (*op. cit.*) reviewed the age of this conodont fauna, together with that of fragmentary megafossils recovered from the core, and concluded that a mid Silurian (Niagaran) age was indicated. Subsequently, Öpik (1959, p. 14) suggested 'that the upper part of the Limestone may extend into the Devonian'. The generally unsatisfactory status of the Lower Palaeozoic subsurface units of the Carnarvon Basin and their doubtful correlation has recently been discussed by Condon (1965).

When these conodont elements were discovered it was not possible for them to provide other than a broad indication of age. Over the last decade, however, knowledge of Silurian conodont faunas has been substantially increased. In particular, Walliser (1962, 1964) has recognized a zonal succession of faunas in the Silurian of Europe, which may also be applied in the Silurian of N. America (Rexroad and Rickard 1965). The conodonts from the Dirk Hartog Limestone may also be referred to Walliser's scheme.

I am obliged to Professor B. F. Glenister, of the State University of Iowa, who passed on the conodont collection for description, and to Mrs B. Pearson, who made the conodont illustrations in Fig. 1. West Australian Petroleum Pty. Limited (WAPET) contributed generously in supporting the publication of this article.

II. Composition of the Fauna

Conodonts were recovered from seven stratigraphic intervals through the formation. These are:

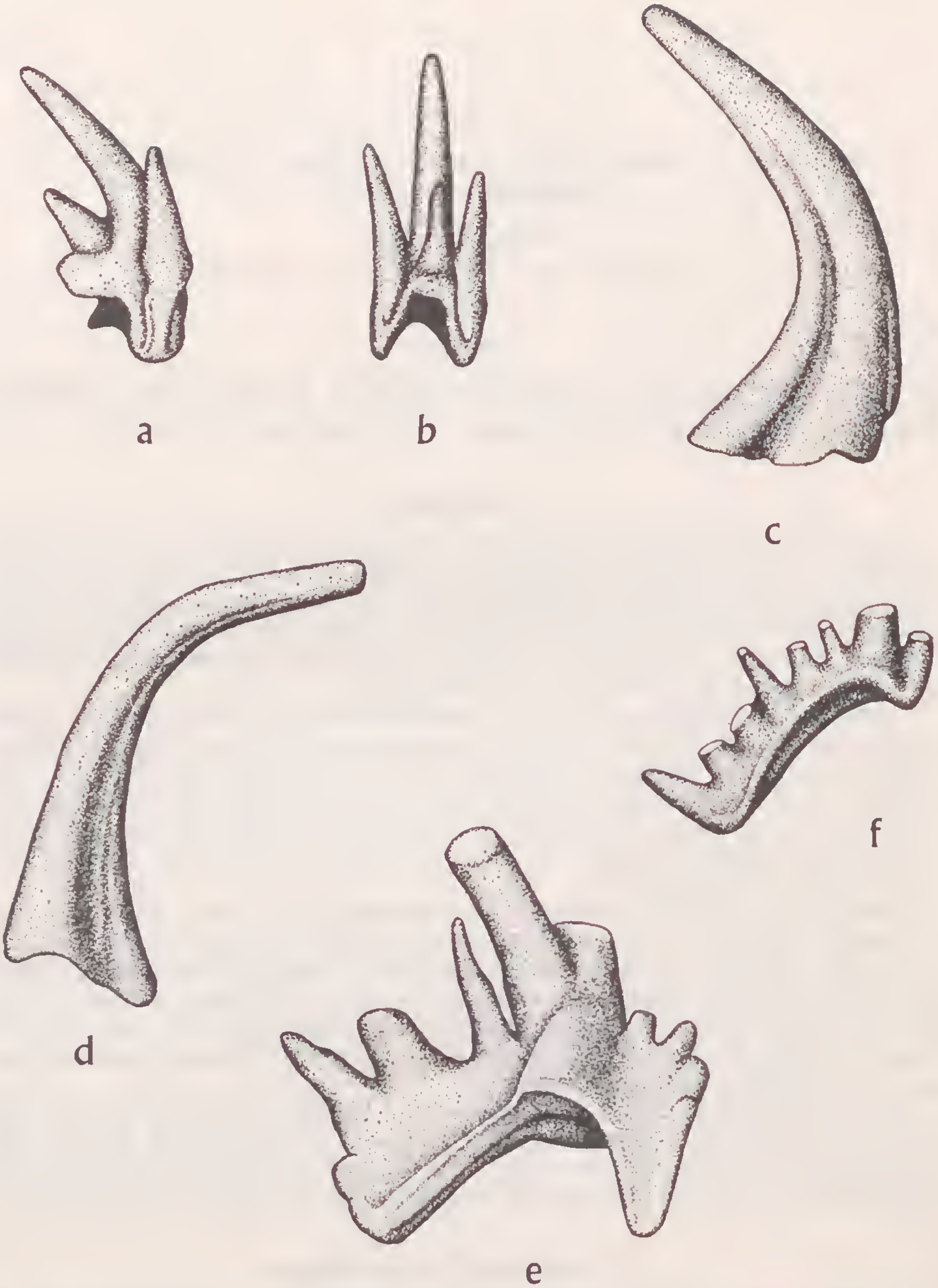

FIG. 1—(a), (b) Lateral and posterior views of *Hibbardella* sp. (c) *Panderodus simplex* (Branson & Mehl); lateral view of 59824. (d) *Panderodus unicostatus* (Branson & Mehl); lateral view of 59820. (e) *Lonchodina greilingi* Walliser; oblique inner view of specimen with double cusp (59812). (f) *Neoprioniodus latidentatus* Walliser; inner lateral view of 59805. Figures × 60 approximately.

Core	Stratigraphic Intervals	Samples
6	2180 ft-2198 ft	7
7	2300 „ -2305 „	6
8	2345 „ -2360 „	5
12	2687 „ -2701 „	4
13	2722 „ -2740 „	3
14	2900 „ -2910 „	2
19	3522 „ -3538 „	1

Hereafter these intervals will be referred to by their sample numbers.

In all there are approximately 200 identifiable conodonts in the collection. Their distribution in the samples is given in Table 1.

Worthy of particular note in the fauna is the number of specimens which exhibit regeneration. The occurrence of this in conodont elements has been discussed previously by Hass (1941), Rhodes (1954) and Lindström (1964). In previously reported examples, the regenerated distal portion of a denticle has a smaller diameter, and the new growth axis may be offset from that of the original denticle. The broken-off portion of the denticle was apparently lost. Rhodes (1954) maintained that this suggests that the elements were exposed in the conodont animal. Lindström (1964), on the other hand, suggested that the broken parts were either expelled from the body of the animal, or were resorbed.

TABLE 1

Distribution of conodont species through the Dirg Hartog Formation

	1	2	3	4	5	6	7
Hibbardella sp.							+
Ligonodina silurica Branson & Mehl				+	?		
Ligonodina sp.				+			
Ligonodina sp. indet.		+				+	
Lonchodina greilingi Walliser				+	+	+	+
Lonchodina walliseri Ziegler				+			
Neoprioniodus bicurvatus (Branson & Mehl)							+
Neoprioniodus latidentatus Walliser	+			+		+	+
Ozarkodina sp. affin. *fundamentata* (Walliser)		?		+			
Ozarkodina jaegeri Walliser							+
Ozarkodina ziegleri tenuiramae Walliser				+	+		
Ozarkodina sp.indet.							+
Panderodus simplex (Branson & Mehl)				+	+	+	
Panderodus unicostatus (Branson & Mehl)				+		+	
Panderodus sp.				+			
Plectospathodus sp.				+			+
Spathognathodus primus (Branson & Mehl)							+
Trichonodella inconstans Walliser				+	?		
Trichonodella symmetrica (Branson & Mehl)				+			
Gen. et sp. indet.	+	+	+	+	+	+	

The specimen of *Lonchodina greilingi* illustrated in Pl. 17, fig. 21 and Fig. 1e is of particular interest. This specimen has a double cusp. The inner cusp is slender and is directed inwards and sideways; the outer cusp is more robust and is more normally directed. The base of the inner cusp is marked by a line of clear material.

It would appear that the specimen represents a conodont element in which the cusp was cracked and so ceased to grow. A new cusp (now represented by the outer, thicker cusp) then developed. The denticles of one of the lateral limbs also show normal regeneration. The specimen would therefore seem to suggest that resorption by the conodont animal of broken pieces of element did not always take place.

III. Age of the Fauna

The bar elements of the fauna provide a clear indication of age in relation to the ranges given by Walliser (1964). Table 2 summarizes the ranges of various species common to the Dirk Hartog Limestone and Europe. Most of these are long ranging Ludlovian species which extend upward into the Lower Devonian. It will be seen, however, that the occurrence of *Ozarkodina ziegleri tenuiramae* and *Ozarkodina* affin. *fundamentata* suggests a broad correlation with the mid Ludlovian *ploekensis* Zone (approximating to the zone of *Monograptus chimaera*). Sample 7, from the top of the formation, contains *Ozarkodina jaegeri* and *Neoprioniodus bicurvatus* which indicate a late Ludlovian age in terms of European occurrences. The absence of representatives of the ubiquitous *Spathognathodus steinhornensis* group in this upper sample would seem to preclude a latest Ludlovian or Devonian age.

The Dirk Hartog Formation, as intersected in the No. 17B test bore, is 2,425 ft thick. The European ranges of conodonts recovered from the top 500 ft of the formation, suggest a mid to late Ludlovian age for this interval. The occurrence of the pentamerid brachiopod *Conchidium* (A. A. Öpik *in* Glenister and Glenister 1957) at a depth of approximately 1,500 ft beneath top of the formation, indicates that at least the uppermost three-fifths of the formation is of Ludlovian age.

In the absence of platformed elements, however, it would be unwise to assign more than a broad Ludlovian age to the Dirk Hartog conodont fauna. Elements in the fauna, such as *Neoprioniodus bicurvatus* (Branson & Mehl), *Spathognathodus primus* (Branson and Mehl), and *Trichonodella symmetrica* (Branson and Mehl), which in Europe appear first in the late Ludlovian (Walliser 1964), were originally described from the Bainbridge Formation of Missouri. Generally this unit is not considered to be younger than early Ludlovian. Indeed, Rexroad's (1967) recent study of Llandoverian conodonts of the Brassfield Formation suggests that similar or identical bar elements are much more long-ranging than is indicated by European occurrences.

IV. Systematics

All specimens are registered in the Palaeontological Collection of the University of Western Australia. The synonymies refer only to primary references and Australian occurrences.

Genus **Hibbardella** Bassler 1925

TYPE SPECIES: *Prioniodus angulata* Hinde 1879.

REMARKS: The confusion which exists in the generic classification of conodont elements which comprise a symmetrical anterior arch with a denticulated posterior bar has been reviewed elsewhere (Philip 1967). After restudy of the type specimen of *Prioniodus angulata* it was concluded that *Hibbardella* should be employed for such forms with a large basal cavity.

Hibbardella sp.

(Fig. 1a-b)

DESCRIPTION: Cusp circular in cross section and recurved posteriorly over the posterior bar. Anterior arch U-shaped, and bearing an upright denticle on each side of the cusp. Posterior bar short with a single, backwardly directed denticle. Basal cavity deeply excavated and continued beneath the posterior bar and the lateral limbs.

TABLE 2

Ranges of Dirk Hartog Limestone species in Europe (Walliser 1964)

	Ludlovian							Gedinnian
	sagitta	crassa	ploeckensis	siluricus	latialatus	crispus	eosteinhornensis	woschmidti
Ligonodina silurica (4)		—	—	—	—	—	—	—
Lonchodina greilingi (4, 7)	—	—	—	—	—	—	—	—
Lonchodina walliseri (4)	—	—	—	—	—	—	—	—
Neoprioniodus latidentatus (4, 7)			—	—	—	—	—	—
Neoprioniodus bicurvatus (7)						—	—	—
Ozarkodina fundamentata (4)		—	—	—				
Ozarkodina jaegeri (7)					—	—	—	
Ozarkodina ziegleri tenuiramae (4)		—	—					
Spathognathodus primus (7)				—	—	—	—	—
Trichonodella inconstans (4)	—	—	—	—	—	—	—	—
Trichonodella symmetrica (4)					—	—	—	

REMARKS: The figured specimen was lost during final curating of the material. Figures are included for completeness as this form does not compare closely with any previously described Silurian species of *Hibbardella*.

Genus **Ligonodina** Bassler 1925

TYPE SPECIES: *Ligonodina pectinata* Ulrich & Bassler 1926.

Ligonodina silurica Branson & Mehl

(Pl. 18, fig. 4, 7-8)

Ligonodina silurica Branson & Mehl 1933, p. 48; Pl. 3, fig. 18-20; Walliser 1964, p. 42; Pl. 8, fig. 13; Pl. 32, fig. 15 (*cum synon.*).

DIAGNOSIS: A species of *Ligonodina* with a relatively short lateral process which is directed normal to the posterior limb. Cusp well-defined and recurved over the posterior limb which bears discrete backwardly inclined denticles; posterior limb usually somewhat upwardly arched.

FIGURED SPECIMENS: 59799-59802.

REMARKS: The other common Silurian species *Ligonodina salopia* Rhodes (1953, p. 307; Pl. 23, fig. 245, 257, 260) has a much longer lateral process which is more anteriorly directed. Recently Rexroad (1967, p. 35) has suggested that this species may be a synonym of the poorly known species *Ligonodina kentuckyensis* Branson & Branson (1947, p. 555; Pl. 82, fig. 28, 35).

A number of very fragmentary specimens in the collection, clearly referable to *Ligonodina*, cannot be identified specifically. In Table 1 they are listed as *Ligonodina* sp. indet.

Ligonodina sp.

(Pl. 18, fig. 4, 7-8)

REMARKS: Several small, delicate specimens in the collection appear to differ from *L. silurica* in that their lateral process is more anteriorly directed and that the posterior limb is shorter and is straight. Conceivably they could represent immature specimens of this species.

FIGURED SPECIMENS: 59796-59798.

Genus **Lonchodina** Bassler 1925

TYPE SPECIES: *Lonchodina typicalis* Bassler 1925.

Lonchodina greilingi Walliser

(Fig. 1e; Pl. 17, fig. 17-18, 21)

Lonchodina greilingi Walliser 1957, p. 38; Pl. 3, fig. 20-26; Walliser, 1964, p. 44; Pl. 8, fig. 7; Pl. 30, fig. 7-8 (*cum synon.*); Philip 1965, p. 104; Pl. 9, fig. 22.

DIAGNOSIS: *Fide* Philip 1965, *loc. cit.*

FIGURED SPECIMENS: 59810-2.

REMARKS: The remarkable regeneration of the cusp, seen in the specimen of this species illustrated in Pl. 17, fig. 21, is discussed in II. Composition of Fauna (above).

Lonchodina walliseri Ziegler

(Pl. 17, fig. 19)

Lonchodina walliseri Ziegler 1960, p. 188; Pl. 14, fig. 1, 3, 7; Walliser 1964, p. 44-45; Pl. 8, fig. 17; Pl. 30, fig. 26-33; Philip 1965, p. 104; Pl. 8, fig. 35.

DIAGNOSIS: *Fide* Philip 1965, *loc. cit.*

FIGURED SPECIMEN: 59813.

Genus **Neoprioniodus** Rhodes & Müller 1956

TYPE SPECIES: *Prioniodus conjunctus* Gunnell 1933.

Neoprioniodus bicurvatus (Branson & Mehl)

(Pl. 17, fig. 15)

Prioniodus bicurvatus Branson & Mehl 1933, p. 44; Pl. 3, fig. 9-12.

Neoprioniodus bicurvatus (Branson & Mehl) Walliser 1964, p. 46; Pl. 9, fig. 13; Pl. 29, fig. 27-33; Fig. 5d (*cum synon.*); Philip 1965, p. 105; Pl. 9, fig. 13, 18, 20; Philip 1966, p. 446; Pl. 3, fig. 12-16.

DIAGNOSIS: *Fide* Philip 1966, *loc. cit.*

FIGURED SPECIMEN: 59789.

Neoprioniodus latidentatus Walliser

(Fig. 1f; Pl. 17, fig. 7-11, 16)

Prioniodina excavata (Branson & Mehl) Walliser 1957, p. 46; Pl 2, fig. 17; Ziegler 1960, p. 192; Pl. 15, fig. 5.
Neoprioniodus latidentatus Walliser 1964, p. 50; Pl. 8, fig. 15; Pl. 29, fig. 34-35, fig. 5b.
Neoprioniodus (?) sp. Philip 1965, p. 105; Pl. 9, fig. 14.
non *Prioniodus excavatus* Branson & Mehl 1933, p. 45; Pl. 3, fig. 7-8.

DIAGNOSIS: A species of *Neoprioniodus* with widely spaced, rounded denticles, and a large basal cavity which is continued as a flat distally tapering groove beneath the posterior limb.

FIGURED SPECIMENS: 59803-59808.

REMARKS: Although the denticulation and the basal cavity of the Dirk Hartog specimens are characteristic of this species, none of the Silurian material described and figured by Walliser (1957, 1964) has the well developed 'anticusp' or anterior limb with discrete denticles seen in the specimens here illustrated. However, Walliser (1964) included in this species the Gedinnian form illustrated by Ziegler (*loc. cit.*) which shows this feature. Furthermore, the Dirk Hartog material indicates that specimens lacking an anticusp may intergrade with forms in which it is well developed. Accordingly, the specimen described by Philip (*loc. cit.*) from the early Devonian of Victoria should be referred to this species. It should be noted that in the smallest available specimens (particularly that illustrated in Pl. 17, fig. 8) the denticles are closely spaced and the basal cavity is relatively smaller.

'*Euprioniodina* cf. *Prioniodus excavata* Branson & Mehl' of Rexroad (1967, p. 31-32; Pl. 3, fig. 7-8) from the Llandoverian of the Cincinnati Arch region is almost identical with the Dirk Hartog material, but differs in the more horizontal, shorter posterior limb. Because of the well defined anterior limb with discrete denticles, Rexroad refers his form to *Euprioniodina*.

Large specimens of *N. latidentatus* in the fauna may resemble *Lonchodina greilingi* (cf. Pl. 17, fig. 16, 18). However, in this latter species the basal cavity continues beneath both of the twisted limbs which tend to be of similar length.

Genus **Ozarkodina** Branson & Mehl 1933

TYPE SPECIES: *Ozarkodina typica* Branson & Mehl 1933.

Ozarkodina fundamentata (Walliser)

Spathognathodus fundamentatus Walliser 1957, p. 48; Pl. 1, fig. 11-14; Walliser 1965, p. 56-57; Pl. 7, fig. 18; Pl. 23, fig. 5-14, fig. 3d, e. (*cum synon.*).

Ozarkodina sp. affin. **O. fundamentata** (Walliser)

(Pl. 18, fig. 1, 6. 11, 13, 17, 21-22)

DESCRIPTION: A bladed, gently arched unit, usually with regular denticles which become progressively inclined toward the posterior end. A denticle toward the posterior end, usually above the basal cavity, is enlarged to give a poorly defined cusp. Basal cavity usually centrally located and continued beneath the posterior limb as a shallow groove; lateral lobes present but not prominent.

FIGURED SPECIMENS: 59774-59780.

REMARKS: Although this element has the general morphology of *O. fundamentata*, it lies outside the range of variation ascribed to the species by Walliser (1964). The Dirk Hartog specimens possess fewer denticles, the posterior limb is not strongly deflected downwards and the basal cavity is more centrally located and has more subdued lateral lobes.

Ozarkodina jaegeri Walliser

(Pl. 17, fig. 20)

Ozarkodina jaegeri Walliser 1964, p. 57-58; Pl. 9, fig. 16; Pl. 25, fig. 11-18, Fig. 3n-o.

Diagnosis: A bladed species of *Ozarkodina* with regularly developed denticles. Anterior limb higher than posterior limb which tends to taper posteriorly. Cusp well defined and centrally located; basal cavity confined to the central part of the unit, usually with small projecting lips.

Figured Specimen: 59814.

Ozarkodina ziegleri Walliser

Diagnosis: An arched species of *Ozarkodina* with somewhat twisted and incurved limbs, the posterior one of which is the lower. Cusp and denticles well developed and also tending to be incurved.

Ozarkodina ziegleri tenuiramae Walliser

(Pl. 18, fig. 5, 10, 16, 20, 26-28)

Ozarkodina ziegleri tenuiramae Walliser 1964, p. 62-63; Pl. 3, fig. 15; Pl. 24, fig. 22-28, Fig. 3g-h.

Diagnosis: A subspecies of *Ozarkodina ziegleri* with relatively low limbs and wide basal cavity which extends as a very flat groove to the posterior end of the unit.

Figured Specimens: 59782-59788.

Remarks: As the available material forms a graded growth series, all specimens are referred to the one subspecies of *O. ziegleri*. It should be noted, however, that in the smaller specimens the basal cavity is not continued to the posterior end of the unit.

Ozarkodina sp. indet.

(Pl. 17, fig. 23)

Description: A very flattened bladed unit with a high anterior bar, the denticles of which become progressively higher toward the backwardly directed cusp. Posterior limb low; basal cavity a tiny depression beneath the cusp.

Figured Specimen: 59815.

Remarks: This single small specimen with an incomplete posterior bar cannot be positively identified. In its general form it resembles most closely *Ozarkodina edithae* Walliser (1964, p. 55-56; Pl. 26, fig. 12-18) but it could rather be an immature specimen of the *Ozarkodina typica* group.

Genus **Panderodus** Ethington 1959

Type Species: *Paltodus unicostatus* Branson & Mehl 1933.

Panderodus simplex (Branson & Mehl)

(Fig. 1c; Pl. 17, fig. 2, 3, 5, 12)

Paltodus simplex Branson & Mehl 1933, p. 42; Pl. 3, fig. 4.

Panderodus simplex (Branson & Mehl), Clark & Ethington 1966, p. 682; Pl. 82, fig. 10, 14 (*cum synon.*).

Paltodus acostatus Branson & Branson 1947, p. 554; Pl. 82, fig. 1-5, 23-24.

Panderodus acostatus (Branson & Branson), Philip 1965, p. 108; Pl. 8, fig. 10, 23, 43; Fig. 2h-i. Philip 1966, p. 447; Pl. 1, fig. 13, 18.

Diagnosis: *Fide* Philip, *loc. cit.*

Figured Specimens: 59822-59825.

Panderodus unicostatus (Branson & Mehl)
(Fig. 1d; Pl. 17, fig. 1, 4, 13-14)

Paltodus unicostatus Branson & Mehl 1933, p. 42; Pl. 3, fig. 3; Philip 1965, p. 109; Pl. 8, figs. 9; Fig. 2g.
Panderodus unicostatus (Branson & Mehl), Clark & Ethington 1966, p. 683; Pl. 82, fig. 17, 19 (*cum synon.*); Philip 1966, p. 447; Pl. 1, fig. 10-12, 19.

DIAGNOSIS: *Fide* Philip *loc. cit.*

FIGURED SPECIMENS: 59818-59821.

Panderodus sp.

REMARKS: A single specimen, apparently referable to *Panderodus*, differs from others in the fauna in the broadly triangular cross section of its shallow basal cavity. Carina are developed at the margins of the flattened anterior face. The specimen resembles most closely *Paltodus dyscritus* Rexroad (1967, pp. 42-44; Pl. 4, fig. 30, 34).

FIGURED SPECIMEN: 59809.

Genus **Spathognathodus** Branson & Mehl 1941

TYPE SPECIES: *Ctenognathus murchinsoni* Pander 1856

Spathognathodus primus (Branson & Mehl)
(Pl. 17, fig. 22, 24)

Spathodus primus Branson & Mehl 1933, p. 46; Pl. 3, fig. 25-30.
Spathognathodus primus (Branson & Mehl) Walliser 1964, p. 80-82; Pl. 8, fig. 14; Pl. 22, fig. 9-25; Pl. 23, fig. 1-4, fig. 8. (*cum synon.*).

DIAGNOSIS: A heavily constructed species of *Spathognathodus*, usually with well defined, somewhat irregular denticles, which tend to be lower at the posterior end of the unit. Lateral lobes small and thickened and usually centrally located.

FIGURED SPECIMENS: 59816-59817.

REMARKS: The extreme variation seen in this species has been described by Walliser (*loc. cit.*). The Dirk Hartog specimens appear to conform most closely to Walliser's *latialatus* Zone forms rather than younger forms. They also closely resemble Branson & Mehl's original material from the Bainbridge Formation of Missouri.

Genus **Trichonodella** Branson & Mehl 1948

TYPE SPECIES: *Trichognathus prima* Branson & Mehl 1933.

Trichonodella inconstans Walliser
(Pl. 18, fig. 9, 12, 14-15)

Trichonodella inconstans Walliser 1957, p. 50; Pl. 3, fig. 10-17; Walliser 1964, p. 90; Pl. 30, fig. 10-12 (*cum synon.*); Philip 1965, p. 112; Pl. 9, fig. 15, 25; Philip 1966, p. 451; Pl. 3, fig. 23; Pl. 4, fig. 21, 23, 27, 30.

DIAGNOSIS: *Fide* Philip 1966, *loc. cit.*

FIGURED SPECIMENS: 59792-59795.

Trichonodella symmetrica (Branson & Mehl)
(Pl. 18, fig. 24)

Trichognathus symmetrica Branson & Mehl 1933, p. 50; Pl. 3, fig. 33-34.
Trichonodella symmetrica (Branson & Mehl) Walliser 1964, p. 90; Pl. 9, fig. 11; Pl. 31, fig. 28-30; Philip 1965, p. 112-113; Pl. 9, fig. 19, 21 (*cum synon.*).

DIAGNOSIS: *Fide* Philip 1965, *loc. cit.*

FIGURED SPECIMEN: 59781.

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Explanation of Plates

All figures × 40

PLATE 17

Fig. 1, 4, 13-14—*Panderodus unicostatus* (Branson & Mehl). (1) 59818; (4) 59819; (13) 59820; (14) 59821. Specimens from Sample 4.

Fig. 2, 3, 5, 12—*Panderodus simplex* (Branson & Mehl). (2) 59822; (3) 59823; (5) 59824; (12) 59825. Specimens from Sample 4.

Fig. 6—*Panderodus* sp. 59809, Sample 7.

Fig. 7-11, 16—*Neoprioniodus latidentatus* Walliser. (7) Inner lateral view of 59803; (8) Inner lateral view of 59804; (9) Inner lateral view of 59805; (10) Inner lateral view of 59806; (11) Inner lateral view of 59807; (16) Inner lateral view of 59808. Specimen from Sample 4.

Fig. 15—*Neoprioniodus bicurvatus* (Branson & Mehl). Inner lateral view of 59789, Sample 7.

Fig. 17-18, 21—*Lonchodina greilingi* Walliser. (17) Inner view of 59810; (18) Inner lateral view of 59811; (21) Inner lateral view of 59812, specimen with a double cusp. Specimens from Sample 4.

Fig. 19—*Lonchodina walliseri* Ziegler. Lateral view of 59813, Sample 7.

Fig. 20—*Ozarkodina jaegeri* Walliser. Lateral view of 59814, Sample 7.

Fig. 22, 24—*Spathognathodus primus* (Branson & Mehl). (22) Lateral view of 59816; (24) Lateral view of 59817, Sample 4.

Fig. 23—*Ozarkodina* sp. Lateral view of 59815, Sample 7.

Plate 18

Fig. 1, 6, 11, 13, 17, 21-22—*Ozarkodina* sp. affin. *O. fundamentata* (Walliser). (1) 59774; (6) 59775; (11) 59776; (13) 59777; (17) 59778; (21) 59779; (22) 59780. Lateral views of specimens from Sample 4.

Fig. 2-3—*Plectospathodus* sp. (2) Inner lateral view of 59790; (3) Inner lateral view of 59791. Specimens from Sample 4.

Fig. 4, 7-8—*Ligonodina* sp. (4) Inner view of 59796; (7) Inner view of 59797; (8) Inner view of 59798. Specimens from Sample 4.

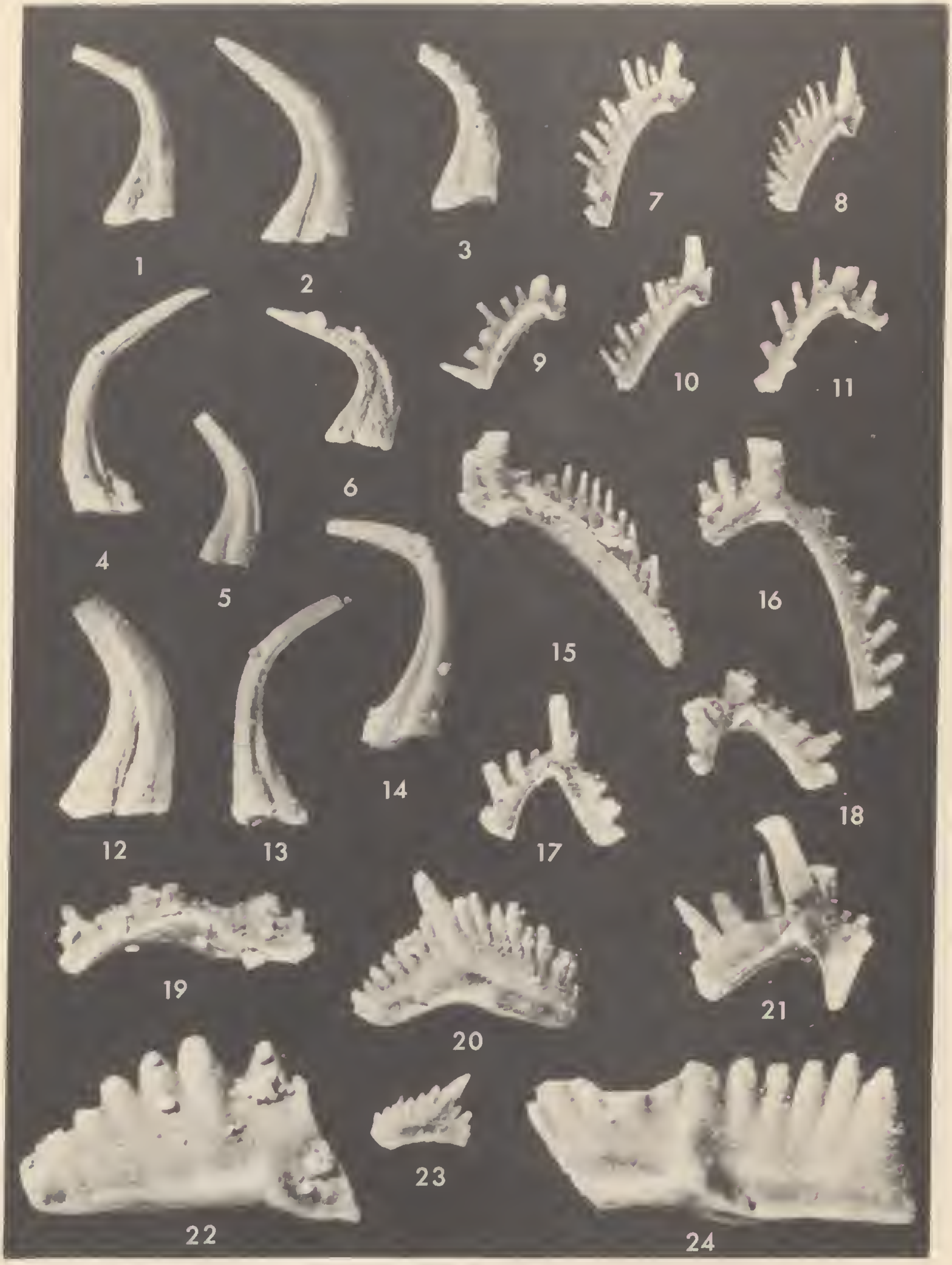
Fig. 5, 10, 16, 20, 26-28—*Ozarkodina ziegleri tenuiramae* Walliser. (5) 59782; (10) 59783; (16) 59784; (20) 59785; (26) 59786; (27) 59787; (28) 59788. Lateral views of specimens from Sample 4.

Fig. 9, 12, 14-15—*Trichonodella inconstans* Walliser. (9) Oblique posterior view of 59792, showing basal cavity; (12) Posterior view of 59793; (14) Posterior view of 59794; (15) Posterior view of 59795. Specimen from Sample 4.

Fig. 18-19, 23, 25—*Ligonodina silurica* Branson & Mehl. (18) 59799; (19) 59800; (23) 59801; (25) 59802. Inner lateral views of fragmentary specimens from Sample 4.

Fig. 24—*Trichonodella symmetrica* (Branson & Mehl). Inner view of 59781, Sample 4.

Fig. 1—(a), (b) Lateral and posterior views of *Hibbardella* sp. (c) *Panderodus simplex* (Branson & Mehl); lateral view of 59824. (d) *Panderodus unicostatus* (Branson & Mehl); lateral view of 59820. (e) *Lonchodina greilingi* Walliser; oblique inner view of specimen with double cusp (59812). (f) *Neoprioniodus latidentatus* Walliser; inner lateral view of 59805. Figs. × 60 approximately.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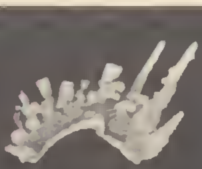
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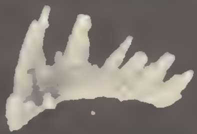
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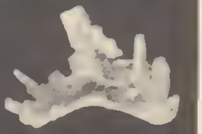
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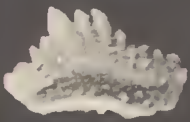
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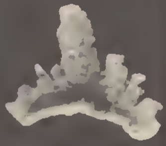
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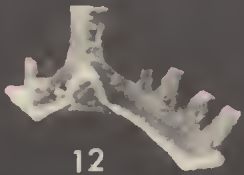
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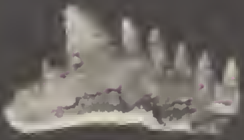
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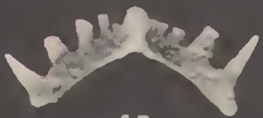
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A NEW SPECIES OF *Gomphocythere* (LIMNOCYTHERIDAE, OSTRACODA) FROM AUSTRALIA

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Abstract

Gomphocythere australica sp. nov. is described, and the chemical characteristics of the environment briefly discussed and compared with the data available for other species.

Introduction

Sars (1924) established the genus *Gomphocythere* to accommodate two African species, *G. obtusata* (Sars) and *G. expansa* Sars. The former had originally been placed by Sars (1910) in the genus *Limnocythere*. Subsequently, seven more species have been described from South Africa (Müller 1921, Lowndes 1932, Klie 1939, 1944, Rome 1962), two species from New Zealand (Brehm 1932, 1939, Hornibrook 1955, Barclay 1968), one from Argentina (Ferguson 1967), and one undescribed species reported from Tasmania (McKenzie 1966). Quite recently, two more undescribed species have been recorded from South Australia.

The present paper describes *Gomphocythere australica* sp. nov. collected by the author from Lake Purrumbete, a volcanic maar, 10 km east of Camperdown in the Western District of Victoria. The first record of *Gomphocythere* from the mainland of Australia is that of Chapman (1967, p. 4, footnote). In a collection of more than 4,560 specimens, the sex ratio was found to be almost 1:1. The presence of males and females throughout the year indicates that reproduction is by syngamy (Kesling 1956). Dissections of ovigerous females have revealed juveniles up to the second larval stage. Relevance of *Gomphocythere* to the hypothesis of Continental Drift has been discussed by McKenzie & Hussainy (1968).

Specimens were collected and preserved in 70% alcohol. Appendages were cleared and mounted in polyvinyl alcohol with chlorozal black. Fig. 1-14 were drawn using a camera lucida.

Systematics

Family LIMNOCYTHERIDAE Klie 1938
Subfamily LIMNOCYTHERINAE Sars 1925
Type-genus **Gomphocythere** Sars 1924
Type-species **Gomphocythere obtusata** (Sars 1924)
(**Limnocythere obtusata** Sars 1910)

Gomphocythere australica sp. nov., Fig. 1-14

MATERIAL EXAMINED

Lake Purrumbete: 25 ♂, 20 ♀, 31.7.67; 21 ♂, 30 ♀, 14.4.68; coll. S. U. Hussainy.

TYPE MATERIAL

Holotype ♀, allotype ♂, Paratype 20 ♀, 20 ♂; National Museum of Victoria

Reg. No. J-194., J-195., J-196 respectively. Holotype and allotype are mounted on microslides. Paratypes are preserved in 70% alcohol.

TYPE LOCALITY

Lake Purrumbete, Victoria, Australia.

DIAGNOSTIC CHARACTERS

Shell of female much larger than that of male, with expanded posterior region for retention and incubation of eggs; ventral surface of shell in both sexes flattened and defined on each side by slightly projecting longitudinal ridge; caudal rami consisting of two thin lamellae each terminating in digitiform pointed lappet with plumose seta at base, posterior edge of each lamella with three short ciliated lobules; copulatory organ of male much larger than other appendages, terminating in irregular quadrangular plate.

DESCRIPTION OF FEMALE (all the drawings are made from the holotype).

Size: length of shell 0·86 mm, height 0·44 mm, width 0·36 mm. Shell rather tumid; seen laterally (Fig. 1) valves irregularly oval with broadly rounded anterior and posterior margin; maximum height 0·56 times length; dorsal margin slightly curved, forming an angular bend just above the eye; ventral margin slightly sinuate in front of the middle; posterior region more tumid than anterior; greatest width viewed dorsally (Fig. 2) 0·66 times length; shell surface reticulated; long hairs along margins except dorsally; anterior margin bearing row of radial pore canals (Fig. 3). Colour of shell: fuscous brown.

Antennule (Fig. 4): six-segmented, rather stout, proximal two segments largest; distal segment prolonged, armed at tip with sensory club fused basally with an adjacent seta 0·25 times longer than club.

Antenna (Fig. 5): four-segmented, natatory setae absent; two-segmented flagellum almost reaching end of claws; claws short and three in number.

Mandible (Fig. 6): strongly toothed; exopodite bearing three plumose setae, two lateral, one terminal.

Maxilla (Fig. 7): with two-segmented maxillary palp, but segmentation not clear; branchial plate with 16 vibratory lobes with plumose setae.

Thoracic legs: third, fourth and fifth (Fig. 8, 9, 10) similar and of slender construction; each terminating in a claw. Caudal rami (Fig. 11) typical of the genus.

DESCRIPTION OF MALE (all the drawings are made from the allotype).

Shell (Fig. 12) smaller than female, compressed, tubercles absent; in dorsal view, posterior region not expanded; ventral ridges strongly developed; copulatory organ (Fig. 13) well developed; penis with a series of chitinous bands, produced terminally to a beak-shaped projection. Length of valve 0·70 mm, height 0·3 mm, width 0·36 mm.

DISCUSSION

G. australica sp. nov. agrees with the generic description of Sars (1924). The principal differences between species of the genus lie in shell characteristics. As seen in Table 1, *G. australica* is comparable with *G. duffi* Hornibrook and *G. obtusata* (Sars) in length. However, *G. australica* differs from *G. duffi* and *G. obtusata* in the shape of the carapace and in the shape of the male genitalia. A prominent reticulated tubercle is present at the postero-dorsal margin of *G. duffi* which is absent in *G. australica*. The shape of the carapace of *G. duffi* is sub-quadrate; it is more ovate in *G. australica*. The shell of *G. australica* is more tumid than *G. obtusata*. The anterior portion of male genitalia in *G. obtusata* is more quadrate than in *G. australica*. On the basis of these differences, there seems to be adequate justification for erecting a new species for the present material.

Ecology

Gomphocythere is primarily a freshwater genus. Of the 15 species known so far, only one species has been recorded in waters with total dissolved solids

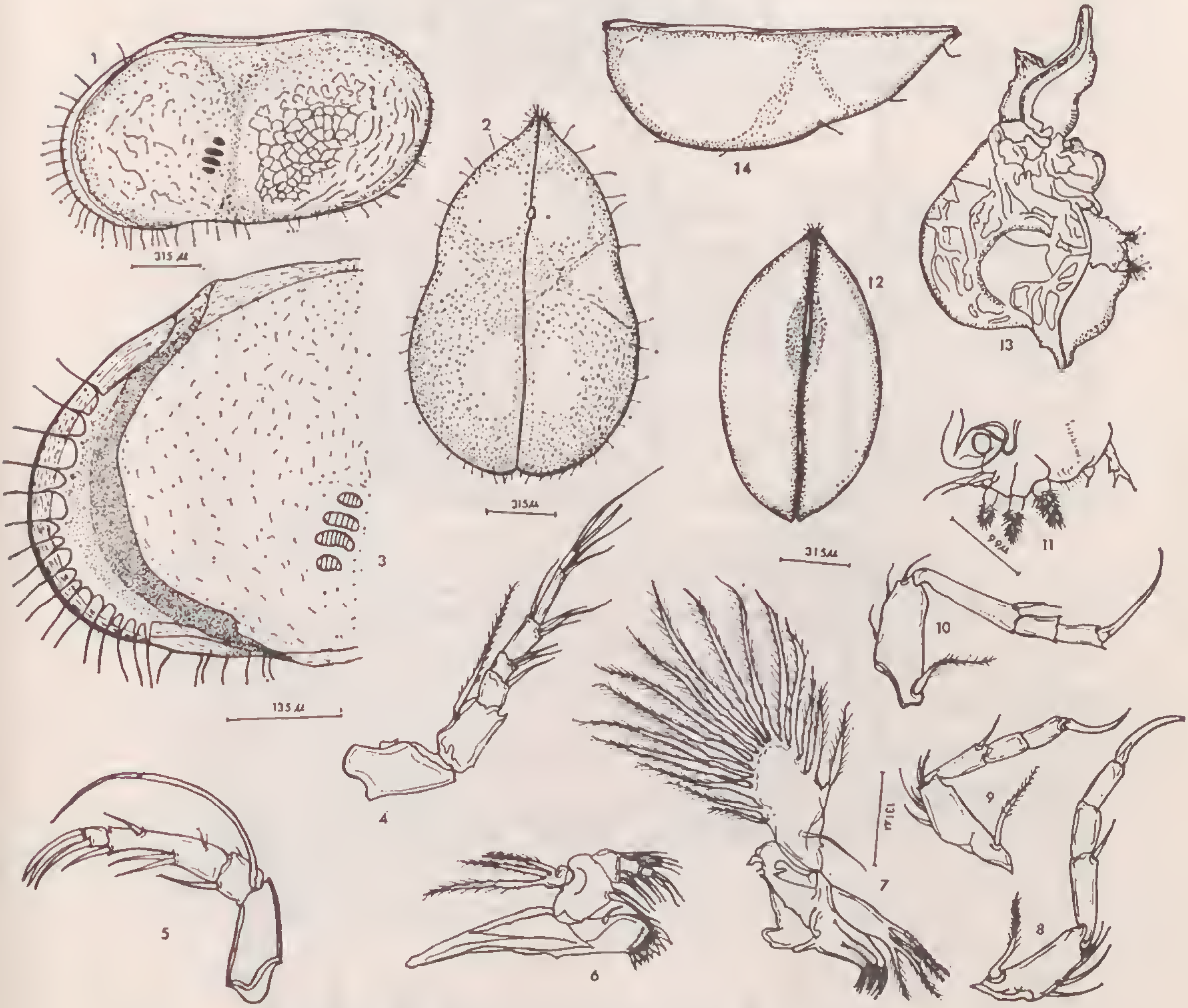

Fig. 1-14—(1) Female carapace, left valve, outer view; (2) Female carapace, dorsal view; (3) Female right valve, anterior portion, inner view; (4) Antennule; (5) Antenna; (6) Mandible; (7) Maxilla; (8) Thoracic leg 1; (9) Thoracic leg 2; (10) Thoracic leg 3; (11) Furca of female; (12) Male carapace, ventral view; (13) Male copulatory organ; (14) Female left valve, ventral view.

TABLE 1

List of known species of Gomphocythere, including data on comparative length of males and females, and on chemical nature of environment

Species	Length of male (mm)	Length of female (mm)	Locality	Country	Total dissolved solids in p.p.m.
G. obtusata	0·70	0·8	Duck-pond at Salt River, Victoria	South Africa	*
G. expansa	0·69	0·77	Pond on the Capeflat	South Africa	†
G. angulata	0·63	0·70	Lake Zwai, Hora Harasadi	South Africa	1940 354
G. cristata	0·50	0·54	Tanganyika	East Africa	420
G. alata	—	0·46	Tanganyika	East Africa	420
G. simplex	—	0·45	Tanganyika	East Africa	420
G. lenis	—	0·44	Tanganyika	East Africa	420
G. curta	—	0·41	Tanganyika	East Africa	420
G. angusta	0·70	0·82	Weedy ponds, high mountains, Kenya	East Africa	†
G. problematica	—	1·00	Waimate Gorge, weedy pool	New Zealand	†
G. duffi	0·68	0·89	Pyramid Valley Swamp	New Zealand	†
G. argentinensis	0·90	1·05-1·08	Madrejon Flores base in the environ of Sante Fe	Argentina	†
G. australica	0·70	0·86	Lake Purrumbete, Victoria	Australia	425
Gomphocythere sp.	—	—	Culvert Lagoon, Tasmania	Australia	6,800

* T.D.S. data not available but $K_{20} = 96$ μmhos.

† T.D.S. data not reported.

(T.D.S.) above 3·0‰ (*Gomphocythere* sp. from the Culvert Lagoon, Tasmania). The T.D.S. of Culvert Lagoon at the time of collection of this species was 6·8‰ (McKenzie 1966). Earlier records show that this value is unusually high for Culvert Lagoon—T.D.S. values of 3·52‰ in 1961 and 4·52‰ in 1962 have been recorded (Williams 1964). Available chemical data for the environment of the species is shown in Table 1. The genus is confined to the Southern hemisphere.

G. australica is endobenthic in habit. The associated microfauna includes *Candonocypris assimilis* Sars, *Cypridopsis* sp., *Cypretta viridis* King, *Diacypris* sp., *Newhamia fenestrata* King and *Macrothrix spinosa* King.

Acknowledgements

I thank Drs W. D. Williams and I. A. E. Bayly, Monash University, for help in the preparation of the manuscript, and Dr K. G. McKenzie (formerly of Monash University but now at British Museum, London) for his help in identification.

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DESCRIPTION OF THE MALE OF *Candonocypris assimilis* G.O. SARS 1894 (CYPRIDAE, OSTRACODA)

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Abstract

The adult male of *Candonocypris assimilis* is described, and the generic and specific descriptions are revised. The associated fauna and flora are noted.

Introduction

During a limnological investigation of some lakes in the western district of Victoria, specimens of *Candonocypris assimilis* G. O. Sars (1894) were collected from Lake Purrumbete, a volcanic maar about 10 km east of Camperdown, Victoria, Australia. The sex ratio in about 1,000 specimens was 1:1. Sars described this species on the basis of females developed from dried mud taken from lagoons in the neighbourhood of Dunedin in New Zealand. In describing the genus *Candonocypris*, he stated that 'propagation is exclusively parthenogenetical'. Similarly, Chapman (1963), who reviewed the ostracod fauna of New Zealand, also mentioned only the presence of females. In Australia, this genus is widely distributed in fresh-water ponds and lagoons (McKenzie and Gill 1968), but this is the first record of the species in this country.

The present paper describes the male. Specimens were dissected in 70% alcohol, cleared and mounted in polyvinyl alcohol, with chlorozol black as a stain. Figures 1-16 were prepared using a camera lucida. Material has been deposited in the National Museum of Victoria, Melbourne, Reg. No. J-193. More than 30 specimens were examined, but all the drawings were made from two specimens.

Description of Male

Males are smaller than females. The length of the male is 1·24 mm whereas the length of the female is 1·60 mm. The carapace is rather oblongreniform in shape, the height about the same anteriorly as posteriorly, and not attaining half the length. The dorsal margin is very slightly and evenly curved, whereas the ventral one exhibits a distinct sinus about the middle. The anterior extremity is more rounded than the posterior one (Fig. 1 and 2).

The valves are unequal, anteriorly the right one overlaps the left by a projecting border defined from the inner duplicature by an elevated ridge (Fig. 1). Posteriorly, on the other hand, no projecting border could be seen when viewed from the left side. The right valve measures 1·24 mm in length and the left valve 1·19 mm. The height of the valve is 0·59 mm.

The shell surface is smooth and polished, carrying at each end delicate hairs projecting beyond the edges (Fig. 2). The muscle scars are very conspicuous and occur considerably in front of the middle of each valve. They are seven in number (Fig. 3). The shell colour is much darker and more fuscous than in the female. Along the sides, behind the muscular pits, obliquely diagonal bands divided in the

FIG. 1-16—(1) Right valve anterior portion enlarged, view from inside; (2) Left valve seen from inside; (3) Muscle scars; (4) Antenna; (5) Mandible; (6) Antennule; (7) Maxilla; (8) Branchial plate of maxilla; (9) Maxilla 2; (10) Thoracic leg 1; (11) Thoracic leg 2; (12) Furca; (13) Genital organ; (14) Zenker's organ; (15) Upper lip; (16) Hypostome showing rake-shaped organ.

middle by narrow stripes are seen. The eye is well developed and easily seen in living specimens.

The several appendages (Fig. 4-11) do not significantly differ in their structure from those of *C. candanoides* (King 1885), the type species, as is the case with other species of this genus.

The caudal ramus (Fig. 12) is rather slender and somewhat attenuated distally, being nearly straight. There are two claws and two setae, both claws are pectinate.

The male ejaculatory duct (Zenker's organ) (Fig. 13) has about 24 chitinous rosettes. The genital organ (Fig. 14) is broad and bilobed anteriorly and measures 0·34 mm in length.

Discussion

Females from the present collections agreed with Sars's description of *C. assimilis* in their size, shape, colour, muscle scar of carapace, natatory setae on the second antennae, and in the shape of the furca. On this basis it is considered that the males present are those of *C. assimilis*. No other species of this genus is known from this locality.

Sars in giving the generic description stated that the 'propagation is exclusively parthenogenetical'. The present record of males warrants deletion of this statement from the generic description. To this description may now be added the fact that the males are smaller than females, and their carapace is more evenly rounded anteriorly than posteriorly. Also the males are much darker and more fuscous than the females, and the olivaceous colour which is fairly common in females is absent in males. The same modification applies to the species diagnosis.

In addition to the present species four more have been described, namely *C. candanoides* (King), *C. bicornis* G. W. Müller, *C. voeltzkowi* G. W. Müller and *C. fitzroyi* McKenzie.

Ecology

Lake Purrumbete is a volcanic maar in the western district of Victoria. The water is fresh, the total dissolved solids varying from 419 to 430 ppm. The annual temperature varies from 10-20°C.

C. assimilis is endobenthic in habit, being found in large numbers in the littoral regions of the lake. The associated microcrustacean fauna includes *Newhamia fenestrata* King, *Cypretta viridis* King, *Diacypris* sp., *Cypridopsis* sp., *Gomphocythere* sp., *Macrothrix spinosa* King, and *Microcyclops* sp.

The known distribution of *C. assimilis* covers New Zealand and Australia. In New Zealand it has been recorded from Lagoons near Dunedin, Duntroon, Awakino Gorge, Swampy Creek and Pyramid Valley. In Australia, Lake Purrumbete is the only known locality for *C. assimilis*.

Acknowledgements

I thank Drs. W. D. Williams and I. A. E. Bayly, Monash University, for help in the preparation of the manuscript, and Dr K. G. McKenzie (formerly of Monash University but now at the British Museum, London) for help in species identification.

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DYASON, MISS D.J. MSC MELBOURNE UNIV., PARKVILLE, VIC. 3052	1960
EALEY, DR. E.H.M. MSC PHD MONASH UNIVERSITY. CLAYTON, VIC. 3168	1961
EARL, C.T. BCE AMIE AUST 46 SCOTT ST., ESSENDON, VIC 3040	1961
EDDY, A.R. BSC MF CALIF ADIPFOR CRES MIFA 950 BOURKE RD., DEEPDENE, VIC. 3103	1963
ELLIOTT W.W. MA BSC 3 CANTERBURY RD. CANTERBURY VIC 3126	1968
ETTERSHANK, DR. G MSC PHD CORNEL DEPT. OF ZOOLOGY MONASH UNIVERSITY, CLAYTON VIC. 3168	1965
EVANS E.H. FAI 153 SUMMERHILL RD GLEN IRIS VIC 3146	1968
FALK MRS.B MA MELB DIPED OXON CENTRE FOR STUDY HIGHER EDUCMELBOURNE UNI PARKVILLE VIC 3052	1968
FARRER, DR. K.T.H. DSC FRIC FRACI FUCHSIA ST., BLACKBURN, VIC. 3130	1966
FEARN-WANNAN, H.J. MSC BED MACE 2 MERLE ST NORTH BLACKBURN, VIC. 3130	1958
FENSHAM, PROFESSOR P.J. MSC PHD ARACI 20 QUARRY RD., MITCHAM, VIC. 3132	1967
FERBER D.I. BA BSC MOBIL OIL AUST LTD 2 CITY RD. MELBOURNE VIC 3000	1968
FERRIER, J.MCN P.O. BOX 20, COLERAINE, VIC. 3315	1960
FITTS SIR CLIVE KT. MD 14 PARLIAMENT PLACE, MELBOURNE, VIC. 3002	1945
FOCKEN, DR. C.M. BSC BME DPHIL, OXON MS COLORADO 20 CARSON ST., KEW, VIC. 3101	1952
FORSTER, PROF. H.C. MAGRSC PHD SCHOOL OF AGRICULTURE MELBOURNE UNI., PARKVILLE VIC. 3052	1954
FOSTER, DR. R.C. BSC HONS PHD LEEDS RIDLEY COLLEGE, THE AVENUE, PARKVILLE VIC. 3052	1967
FOX, DR. F.A. BSC. FIM 4 SOUTH RD. BRIGHTON BEACH. VIC. 3186	1958
FRANKENBURG, R.S. BSC ZOOLOGY DEPARTMENT, UNIVERSITY MELB, PARKVILLE VIC. 3052	1966
FREAKE, R. 117 MILLSWYN ST., SOUTH YARRA, VIC. 3141	1961
FRY, DR. E. BDSC DDSC MUENSTER 67 WILLIAMS RD., WINDSOR, VIC. 3181	1961
GALLUS, DR. A. PHD BUDAPEST DJUR SZEGED, 2 PATTERSON ST., NUNAWADING, VIC 3131	1963
GARRAN, DR.R.R. MSC PHD FRACI 21 BAMBRA RD., CAULFIELD VIC. 3162	1954
GARNET, J.ROS 23 CAMDON ST., PASCOE VALE, VIC. 3044	1965
GARRETT, B.K. FLAT 2, 28 FULTON ST., BALACLAVA, VIC. 3183	1965
GARTSIDE D.F. BSC ZOOLOGY DEPT MELBOURNE UNI PARKVILLE VIC 3052	1968
GASKIN, A.J. MSC 6 BURNS ST., ELWOOD, VIC. 3184	1941
GEORGE, A.M. BSC 15A KYEAMBA GROVE TOORAK, VIC. 3142	1963
GIBBONS, F.R. BSC 'SHERBURN' ARUNDEL RD., PARK ORCHARDS, VIC. 3114	1963

GIBBS W MSC MSMIT BUREAU OF METEOROLOGY 2 DRUMMOND ST CARLTON VIC 3053	1963
GILL, E.D. BA BD FGS FRGS NAT MUS VIC 285 RUSSELL ST.,MELBOURNE, VIC. 3000	1938
GILMOUR A.J. BSC HONS FISH A WILD DEPT 605 FLIN STMELBOURNE VIC. 3000	1968
GLADWELL, R.A. 32 STUDLEY AVE., KEW, VIC. 3101	1938
GLEN J.B. BSC PHD FLAT 4 70 NIRVANA AVE EAST MALVERN VIC 3145	1968
GLOE, C. MSC 9 COLLINS ST., MENTONE, VIC. 3194	1944
GOODE, D.W. 3 MANDEVILLE CRESCENT, TOORAK, VIC. 3142	1968
GORDON, A. BSC MARLBOROUGH ST,, MONT ALBERT, VIC. 3127	1961
GOTTLIEB, L. DIPMECHE HAMBURG 17 LAVER ST., KEW, VIC. 3101	1958
GOUDIE, A.G. BAGRSC MURCHISON RD., TATURA, VIC. 3616	1941
GRANT, K. BSC 4 HENLY DRIVE, GLEN WAVERLEY, VIC. 3150	1962
GRIFFITHS, DR. A.F. MB BS 1451 BURKE RD. NORTH, EAST KEW VIC. 3102	1961
GRIFFITHS, DR. D.J. BSC PHD WALES MIBIOL SCH BIO SC LA TROBE UNIV., BUNDOORA. VIC, 3083	1968
GROSE, DR. R.J. BSCFOR, DIPFOR AMIFA 453 LA TROBE ST., MELBOURNE VIC. 3000	1960
GROUNDS SIR.ROY KBE BARCH FRAIA FRVIA 100 ST KILDA RD MELBOURNE, VIC. 3004	1958
GRUBB, DR. P.L.C. BSC PHD CSIRO MIN INVT UNI OF MELB.,PARKVILLE, VIC. 3052	1964
GUNSON DR.M.M. MSC PHD ZOOLOGY DEPT UNI OF MELB., PARKVILLE, VIC. 3052	1944
HACK, J.B. BSC 414 COLLINS ST., MELBOURNE, VIC. 3000	1957
HANDBY, P.L. 34 AVONDALE CRESCENT, MORWELL, VIC. 3840	1966
HANCOCK, J.S. BSC FLAT 4, 80 MATHOURA RD., TOORAK, VIC. 3142	1965
HARRIS, I.C. ADIPFOR 32 TAWONGA GROVE, MT. BEAUTY, VIC. 3699	1967
HARRISON, M. OBE 3 CHARLES ST., KEW, VIC. 3101	1964
HARTMANN, N. % JAS BELL MACH CO PTY LTD.,352 MACAULEY RD, KENSINGTON,VIC. 3031	1956
HARTUNG, PROF. E.J. DSC PHD LAVENDER FARM, WOODEND, VIC. 3442	1923
HAVYATT MRS.J.U. FLAT 18 75 QUEENS RD. MELBOURNE VIC 3004	1968
HAWKINS, I.E. 68 LLOYD ST. STRATHMORE, VIC. 3041	1966
HAYDEN MRS. ELIZABETH BSC A.N.U. BOTANY DEPT. P.O. 4 CANBERRA A.C.T. 2600	1967
HAYES A.B. DIPCHEMENG ASTC ARACI AMIEA 53 LANSDOWNE ST. NORTH BALWYN VIC 3104	1968
HEAD, W.C.E. BA DIPED P.O. BOX127, NUMURKAH VIC. 3636	1931
HIBBERD A.R. PHC FPS MRSH 50 VICTORIA CRESCENT MONT ALBERT 3127	1968
HILLEBRAND P.W. TPTC 14 DOUGLAS ST. TOORAK VIC 3142	1968
HILLS PROF. E.S. DSC PHD FRS FAA GEO DEPT UNI OF MELB., PARKVILLE VIC. 3052	1928
HIRD, B.J.W. DIPCIVENG 15 FORSTER ST., MITCHAM, VIC. 3132	1963
HOCKING, J.B. BSC(HONS) 20 ROTORUA ST., SOUTH CAULFIELD VIC 3162	1963
HOGAN, T.W. MAGRSC 100 RIVERSDALE RD., HAWTHORN, VIC. 3122	1947
HOLBEACH, P.W. BAGRSC 435 WATTLETREE RD., EAST MALVERN, VIC. 3145	1967
HOLDAWAY, E.A. BSC BED C/O DEPT. OF ED. ADMIN. UNI. ALB. EDMONTON, ALBERTA CANADA.	1957
HOLLAND, R.A. FLAT 1, 126 ALBERT ST., EAST MELBOURNE. 3002	1931
HOLMES, A.J. BSC BED 7 COLLETT AVE., RINGWOOD, VIC. 3134	1949

HOPE, G. BSC BOTANY SCHOOL, UNI. OF MELB., PARKVILLE, VIC. 3052	1967
HOSKING, DR. C.G.S. MB BS STATION ST., YEA, VIC. 3717	1966
HOWARD, J.A. BSC(WALES) MFOR(MINN) DIPFOR FLS SCHOOL OF FORESTRY, UNI. OF MELB., PARKVILLE, VIC. 3052	1965
JACK, J.B. BSCFOR ADIPFOR 9 GLENDALE RD., SURREY HILLS, VIC. 3127	1967
JACOBSON G. BSC GEOLOGICAL SURVEY OFFICE KOTA KINABALU SABAH MALAYSIA	1968
JEFFREYS, R.B. BSC FRACI 3 ULTIMO COURT, TOORAK, VIC. 3142	1961
JENKIN, DR.J.J. MSC PHD 28 KERR ST., BLACKBURN. VIC. 3130	1945
JENKINS, R.J. 16 SOMERS ST., NORTH BRIGHTON. S.A. 5048	1968
JENSZ, R.L. BSC DEVON RD., EAST DONCASTER, VIC. 3109	1961
JOBLING, W.J. BSC 25 CLONMORE ST., BEAUMARIS, VIC. 3193	1965
JOHNSON, T.J.P. BA DIPED PRIVATE BAG 29, HAMILTON, VIC. 3300	1964
JONES, DR. L.H.P. B AGRSC MSC PHD G.R.I. HURLEY, MAIDENHEAD N.BERKSHIRE, ENGLAND.	1948
JONES, N.L. 7 KINGSTON ST., HAMPTON, VIC. 3188	1963
JONES, DR. R. MSC C/O RIVERINA LABORATORY, CSIRO DENILIQUIN, N.S.W. 2710	1967
JONES, K.A. BCOM 28 SCOTT ST., BEAUMARIS, VIC. 3193	1956
JOYCE, E.B. BSC GEOLOGY DEPT. MELB. UNI. PARKVILLE, VIC. 3052	1963
KAUFMANN, G.A. BA FLAT 20, 28 WATTLE RD., HAWTHORN, VIC. 3122	1958
KEMPSON, F.A. SMIRE 14 DRUMMOND ST., BLACKBURN SOUTH, VIC. 3130	1958
KIDD G.P. BE BSC FLAT 22 47 HANOVER ST. FITZROY VIC 3062	1968
KIMPTON, V.Y. 16 LANSELL RD., TOORAK VIC 3142	1946
KIMPTON W.S. BE MELB 11 HENDERSON AVE MALVERN VIC 3114	1968
KING G. DRYSDALE RD. WARRANDYTE VIC 3113	1968
KIRKMAN, DR.J.W. MBBS 227 CHARMAN RD., CHELTENHAM, VIC. 3192	1965
KLARIC, R. 10 LWR HEIDELBERG RD., IVANHOE, VIC. 3079	1964
KLOOT, N.H. MSC 636 GILBERT RD., RESERVOIR, VIC. 3073	1964
KNIGHT, J.L. 72 STRATHALLAN RD., MACLEOD, VIC. 3085	1944
LANG, DR. P.S. BAGRSC PHD "TITANGA" LISMORE, VIC 3324	1938
LANGDON, C.C. 411 BEACH RD., BEAUMARIS, VIC. 3193	1954
LARKMAN, B.H. 42 ABBEY WALK, VERMONT, VIC. 3133	1967
LAW, DR. P.G. CBE DAPPSC MSC FAIP V.I.C. 258 LT.BOURKE ST., MELBOURNE, VIC. 3000	1946
LEE, H.M. MRS. MSC 54 FITZGIBBON ST., PARKVILLE, VIC. 3052	1957
LEE, F.M. MIE(AUST) 30 CHURCHILL ST., MONT ALBERT, VIC. 3127	1958
LEEPER, PROF. G.W. MSC FLAT E6,89 O'SHANNASSY ST NORTH MELBOURNE VIC 3051	1931
LEESON, L.E. 7 TAGELL RD., RINGWOOD EAST. VIC. 3135	1968
LESLIE, A.J. BAGRSC ADIPFOR 35 QUIROS ST., REDHILL, A.C.T. 2603	1958
LEY, J.B.K. BCE AMICE 30 COSHAM ST., BRIGHTON, VIC. 3186	1958
LIDDY, J.C. BSC FLAT 1,97 CAMBERWELL RD., CAMBERWELL, VIC. 3124	1959
LINDNER, A.W. MSC % AMOSEAS, BOX 13, THE HAGUE. NETHERLANDS.	1959

LING, DR.J.K. MSC PHD DEPT OF ZOOLOGY, MASSEY UNI.PALMERSTON NORTH,N.Z.	1959
LINK, A.G. GEOLOGY DEPARTMENT, NATIONAL UNIVERSITY, A.C.T. 2600	1963
LITTLEJOHN, DR.M.J. PHD DEPT. OF ZOOLOGY, MELBUNI, PARKVILLE, VIC. 3052	1960
LYNCH, D.D. MSC INLAND FISHERIES COMM., 127 DAVEY ST., HOBART. TAS. 7000	1950
MACUMBER, P.G. BSC 115 RIVERSDALE RD., CAMBERWELL, VIC. 3124	1965
MAKRAM, A.E. BSC FLAT 5, 8 JOHN ST., ELWOOD, VIC. 3184	1967
MALCOLMSON R.D. MBE BSC AINSTP 250 ORRONG ROAD TOORAK VIC 3142	1968
MANDELL DR.T MBBS 35 CLIVEJAY ST MOUNT WAVERLEY VIC 3149	1968
MANNING, DR. N.C. BSC PHD MPS VIC. COLLEGE OF PHARMACY. ROYAL PARADE. PARKVILLE, VIC. 3052	1960
MARRIOTT F.A. 28 THE RIGHI SOUTH YARRA VIC 3141	1968
MARTIN MRS.A.M MSC %ICIANZ LTD NEWSOM ST ASCOT VALE VIC 3032	1968
MARTIN G B.ARCH 1 OXFORD COURT IVANHOE VIC 3079	1968
MARTIN, M.J. 5 COOBA ST., CANTERBURY, VIC. 3126	1957
MARTIN, A.A. BSC(HONS) RAND ZOOLOGY DEPARTMENT, UNI. OF MELB. PARKVILLE, VIC. 3052	1966
MATHEWS, A.G. BSC 58 GARTON ST., NORTH CARLTON, VIC. 3054	1961
MATTHEWS, R.T. MSC GEOLOGY DEPARTMENT, UNI. OF MELB. PARKVILLE. VIC. 3052	1965
MCANDREW DR.J. BSC PHD CSIRO MIN INVT UNI OF MELB.,PARKVILLE VIC. 3052	1953
MACCALLUM PROF.SIR PETER MC MA MSC MB CHB DPH 91 PRINCESS ST., KEW, VIC. 3101	1925
MCCAUSLAND M.E.R. FL5 'BURLEIGH' 566 TOORAK RDTOORAK. VIC. 3142	1953
MCCAUGHEY THE REV DR.J.D MA.DD. ORMOND COLLEGE PARKVILLE VIC 3052	1968
MCDONALD, DR.J.A. MSC(MAN) PHD(WIS) 100 VASEY CRESCENT CAMPBELL ACT 2601	1965
MCDONALD V.R HDA HDD FIDM 41 MALIN ST KEW VIC 3101	1968
MCEVEY, A.R. BA NAT MUS VIC RUSSELL ST., MELBOURNE VIC. 3000	1960
MCKENZIE, DR. K.G. BSC PHD DEPT ZOOLOGY MONASH UNIV., P.O. BOX 92, CLAYTON. VIC. 3168	1965
MCKINTY, J.A. MIFA P.O. BOX 87, HEALESVILLE, VIC. 3777	1968
MCLAREN DR.A.C BSC PHD CANTAB 2 GLENBROOK AVE EAST MALVERN VIC 3145	1960
MCLAUGHLIN, DR. R.J.W. MSC PHD(CANTAB) DEPT OF GEO UNI OF MELB., PARKVILLE, VIC. 3052	1963
MCLENNAN, SIR IAN KBE BEE % BHP 500 BOURKE ST., MELBOURNE, VIC. 3000	1960
MCLISTER, H.D.R. 2 LUCAN ST., CAULFIELD, VIC. 3162	1959
MCNALLY, J. MSC 3 ARCADIA ST., BOX HILL, VIC. 3128	1950
MEDWELL G.J. BSC 'HILLVIEW', WIRTH ST., FLORA HILL, BENDIGO. VIC. 3550	1965
MENHENNITT THE HON.MR JUSTICE C.I. LLM.QC JUDGES CHAMBERS MELBOURNE VIC 3000	1968
MENTHA MRS. I. M. BSC 22, EMERALD ST., WEST ESSENDON, VIC. 3040	1968
MIDDLETON, W.G.D. ADIPFOR 81 WIMMERA ST., DIMBOOLA, VIC. 3414	1964
MILLER F.L. MPS BSC PHD 48 FIRST AVE., KEW, VIC. 3101	1962
MILLER, DR.R.H. BSC DIPED 569 WHITEHORSE RD., SURREY HILLS VIC. 3127	1965
MILLIKAN, DR. C.R. DSC VICTORIAN PLANT RESEARCH INSSWAN ST.BURNLEY VIC 3121	1941
MITCHELL A.W.L. BSC 'TIMBER TOP', MANSFIELD, VIC. 3722	1946

MITCHELL, A. BAGRSC 6, GRANGE AVE., CANTERBURY, VIC. 3126	1962
MITCHELL R.G. DIP JOUR 21 DUFF ST SANDRINGHAM VIC 3191	1968
MOIR, MRS. M.M. MA DIPED 434 ELGAR RD., BOX HILL VIC. 3128	1960
MOORE K.BYRON 11 MONA PLACE SOUTH YARRA VIC 3141	1945
MOORE, B.G. BSC MSC % MR. G.A. MOORE, 6 SYMONDS ST., HAWTHORN EASTVIC. 3123	1957
MORGAN, W.G, BCE 18,NAN ST., BOX HILL, VIC. 3128	1961
MORGAN, D.G. BSC DIPED SECONDARY TEACHERS COLLEGE, UNIV OF MELB., PARKVILLE, VIC. 3052	1959
MORLEY, N.W. BSC BED MELB NATIONAL MUSEUM OF VICTORIA,RUSSELL ST., MELBOURNE VIC. 3000	1968
MORRISON, PROFESSOR J.D. PHD DSC FAA LA TROBE UNIVERSITY, BUNDOORA, VIC. 3083	1958
MOSHINSKY N LLB.BA 36 GARTON ST NORTH CARLTON VIC 3054	1968
MOYE, D.G. BSC 36 SYLVANDER ST., NORTH BALWYN, VIC. 3104	1967
MULVANEY, D.J. MA DEPT. OF ANTHROPOLOGY, AUST. NAT. UNIV., CANBERRA, ACT. 2600	1957
MURRAY, MISS F.V. MSC 13,GAYNOR COURT, MALVERN, VIC. 3144	1964
MUSHIN, DR. ROSE MSC PHD SCHOOL OF BACTERIOLOGY, MELBOURNE UNIV. PARKVILLE VIC, 3052	1942
MYER, S. BALLIEU TOORAK, 2 GRANT AVE., VIC. 3142	1965
NEALES T.F. MA PHD 45 WHITE ST EAST KEW VIC 3102	1968
NEBOISS, A. MSC NATIONAL MUSEUM OF VICTORIA,RUSSELL ST., MELBOURNE VIC 3000	1957
NEWNHAM, I.E. MBE MSC % CSIRO DIV. OF MIN. CHEM. P.O. BOX 124, PORT MELBOURNEVIC, 3207.	1961
NICHOLAS, J.R. BSC BED MACE 'CHURINGA' INGRAM'S RD., RESEARCH, VIC. 3095	1964
NIELSEN, MISS B.J. MSC 45 SUMMERHILL RD., GLEN IRIS, VIC. 3146	1954
NOTMAN, G.C. DFC MT. WIDDERIN, SKIPTON, VIC. 3361	1964
NYE, E.E. BSC COLLEGE OF PHARMACY, 381 ROYAL PARADE, PARKVILLE,VIC. 3052	1932
NYOEGER, E. 173 LOWER DANDENONG RD., MENTONE, VIC. 3194	1963
O'BRIEN, DR. T.P. 10 PARK RD., MOUNT WAVERLEY. VIC. 3149	1968
OLSEN C.O. BA DIPED C/O UNESCO, P.O. BOX 5, KABUL, AFGHANISTAN.	1945
OMAN, J.R. 'ROCKBANK', LISMORE, VIC. 3324	1965
O'NEILL, I.C. BCE MENGSCI DIPTRP 10 MURIEL ST., BURWOOD, VIC. 3125	1965
OPPENHEIM R.C. BSC ARACI CHEMISTRY DEPT UNIVERSITY OFMELBOURNE PARKVILLE VIC 3052	1968
ORR, DR. R.G. MA BCH 9 HEYINGTON PLACE, TOORAK VIC. 3142	1935
PAINE, D.W.M. BSCFOR 17 LODDEN ST., BOX HILL, VIC. 3128	1961
PARKER, C.D, BSC DIPBACT (LOND) FRACS 47 OUTLOOK DRIVE, EAGLEMONT, VIC. 3084	1957
PARRY, DR. R.H.G. BCE MESC PHD UNIVERSITY ENGINEERING LABS.CAMBRIDGE UNI., CAMBRIDGE. ENGLAND.	1959
PARSONS, DR. R.F. BSC ADEL PHD MELB GEOGRAPHY DEPT. MELBOURNE U.PARKVILLE, VIC, 3052	1967
PARTRIDGE, MISS J. BSC ZOOLOGY DEPARTMENT, MONASH UNIVERSITY, CLAYTON, VIC. 3168	1967
PASCOE J.R. YARRA VALLEY C OF E SCHOOL RINGWOOD VIC 3134	1968
PAUL V.L. BSC 11 PALM COURT LOWER TEMPLESTOWE VIC 3107	1968
PEARCE, T.S. BSC 67 JOHN ST., ELTHAM, VIC. 3095	1967
PEDDER DR. A.E.H. MA CANTAB. INST SEDIMENT & PETROL GEOL.3303 33RD NW CALGARY ALBERTACANADA.	1965

PERDRIX J.L. FRAS 43 WILLIAM ST. BOX HILL, VIC. 3128	1961
PERRY DR. T.M. BA PHD GEOGRAPHY DEPARTMENT, MELBOURNE UNI., PARKVILLE. VIC. 3052	1964
PERRIMAN A.E. BSC CSIRO DIV. CHEMICAL PHYSICS.P.O. BOX 160. CLAYTON, VIC. 3168	1965
PESCOTT 8.T.M. MAGRSC ROYAL BOTANIC GARDENS, SOUTH YARRA, VIC. 3141	1961
PETERSON, G.T. PHC FPS 59 EAST BOUNDARY RD., EAST BENTLEIGH, VIC. 3165	1958
PETERSON J.A. MSC 17 ARNOTT ST CLAYTON VIC 3168	1968
PHILIP, PROF. G.M. MSC PHD DEPARTMENT OF GEOLOGY., NEW ENGLAND UNI., ARMIDALE, N.S.W. 2350	1955
PIZZEY G CERES RED HILL VIC 3937	1968
PLAYFORD, DR. M. MSC PHD(CANTAB) DEPARTMENT OF GEOLOGY, QLD. UNI., ST. LUCIA, QLD. 4067	1959
POLLITT, J.H. DIP NSTR C/O MR. J. FEATHERSTONE, 5 BURNIE ST., TOORAK, VIC. 3142	1964
POTTER, SIR W. IAN BEC 30 SARGOOD ST., TOORAK 3142	1957
PRESTON, H.E. 47 HAIG ST., BOX HILL SOUTH, VIC. 3128	1949
PROCTOR, DR. C.R. MB BS FFARACS C/O PHARMACEUTICALS DIVISIONICIANZ LTD. BOX 1911, MELB. VIC. 3001	1968
PRYLES M.C. LLM 4 BURNE COURT KEW VIC 3101	1968
PURNELL, W.E. FRACI 30 CURRAGONG AVE., CAMBERWELL, VIC. 3124	1960
RADE, J. MSC FLAT 28A, 601 ST. KILDA RD., MELBOURNEVIC. 3004	1961
RAPAPORT, RABBI DR. I MPHIL PHD 8 MARNE ST., SOUTH YARRA, VIC. 3141	1965
RAWLINSON P.A. MSC SCHOOL OF BIOLOGICAL SCIENCELATROBE UNIV BUNDOORA VIC 3083	1966
RAYNER, J.M. BSC 5 TENNYSON CRESCENT, FOREST, CANBERRA A.C.T. 2603	1957
READ, T.A. FSTC FRACI MAUSIMM 15 CHATFIELD AVE., BALWYN, VIC. 3103	1960
REES, DR. A.L. DSC PHD C/O CSIRO DIV. OF CHEM PHYS.P.O.BOX 160, CLAYTON VIC. 3168	1956
REICHL MRS.P BA HONS DIPED 3 ST.JAMES AVE MONT ALBERT VIC 3127	1968
REID, J.T. FLAT1 159 COTHAM RD., KEW, 3101	1954
RESCH, DR. C.E. BSC PHD C/O 16 BOUVERIE ST., CARLTON, VIC. 3053	1957
REYNOLDS, L.A. BCE MICE MIE AUST MINSTT 57 RIVERSDALE RD., HAWTHORN, VIC. 3122	1967
RICHARDS DR.S.M BSC.PHD % COMINCO LTD P.O.BOX 1605 REGINA SASKATCHEWAN CANADA	1964
RICHARDSON, DR. J.R. MA PHD 16 RAVEN ST., KEW. VIC. 3101	1958
RIGBY, J.F. BSC 152 HOLLAND RD. BLACKBURN SOUTH VIC. 3130	1953
RITCHIE, J.A. OCEAN GROVE, VIC. 3226	1964
ROBERTSON A.G. BE MIE AUST M.M.B.W. 110 SPENCER ST., MELB. VIC. 3000	1967
ROSENBERG, D. C/O T. NELSON (AUST) LTD., 597 LT. COLLINS ST., MELB. VIC. 3000	1964
ROUSE J.L. BA MSC PHD AINSTP FAIP PHYSICS SCHOOL MELBOURNE UNIPARKVILLE VIC 3052	1968
ROWE R.N. BAGSC MSC PHD 23 IRONBARK DRIVE LOWER TEMPLESTOWE VIC 3107	1968
ROWNEY, G. BSC 4 RIDDLE ST., BENTLEIGH, VIC. 3204	1952
RULE A.A.N MIR MSXT 12 THE CRESCENT SURREY HILLS VIC 3127	1964
SALTER N.V. 13 MERCER ROAD ARMADALE 3143	1968
SANDIE, R.B. BCE MENGSC AMIE AUST 25 MOSELLE ST., MONT ALBERT NORTH. VIC. 3129	1965

SAUNDERS W.A.J. BSC HONS 224 WARRIGAL RD. BURWOOD, VIC 3125	1964
SCHOENHEIMER H.P. BA MED MACE 12 MARGARET AVENUE MONTMORENCY 3094	1968
SCHOFIELD PROF. G.C. MD DPHIL DEPARTMENT OF ANATOMY, MONASH UNI. CLAYTON VIC. 3168	1964
SCHLEIGER, N.W. BSC BED 1 ASTLEY ST., MONTMORENCY, VIC 3094	1949
SCOTT, A.R. BE AMIE 10 VERDANT AVE., TOORAK, VIC. 3142	1958
SCURFIELD, DR. G. BSC PHD DIVISION OF FOREST PRODUCTS,CSIRO, YARRA BANK RD STH.MLBVIC 3205	1963
SEEGER R.C. 59 JENKINS ST., NORTHCOTE, VIC 3070	1946
SEGALL, M.B. 89 MONT ALBERT RD., CANTERBURY, VIC. 3126	1968
SEITZ MISS P BA FLAT 15 19 NICHOLSON STREEFITZROY 3065	1968
SELBY, B.A. BSC ARACI 19 CHESTERFIELD AVE., MALVERN, VIC. 3144	1958
SHERGOLD DR J.H. PHD BUREAU OF MINERAL RESOURCES,P.O. BOX 378 CANBERRA A.C.T. 2600	1967
SIMPFENDORFER K.J. DIPFOR MSCF MIFA 55 MARTIN ROAD GLEN IRIS VIC 3146	1968
SIMPSON B.F. BSC ARACI 63 CHAPMAN ST SUNSHINE VIC 3020	1968
SIMPSON, H.P. 3 KNUTSFORD ST., BALWYN, VIC. 3103	1948
SINGLETON, DR. O.P. MSC PHD GEOLOGY DEPARTMENT, MELBOURNE UNIVERSITY PKVLLE VIC. 3052	1943
SKINNER, R.G.B. LLB 111 CHARLES ST., PRAHRAN, VIC. 3181	1960
SKLOVSKY, DR. G.A. INGCHEMISCIL LICSCI INGDOC LYONS, 69 PROSPECT HILL RD., CAMBERWELL, VIC. 3124	1963
SLACK-SMITH, R.J. BSC 7 KINGSTON ST., SHENTON PARK W.A. 6008	1960
SMITH, DR. L.H. MSC DPHIL FRACI 36 DUKE ST., KEW, VIC. 3101	1958
SMITH, E.H. DIPSOCSTUD ADEL 17 HELWIG AVE., MONTMORENCY, VIC. 3094	1963
SMITH, DR. B.J. BSC PHD WALES NATIONAL MUSEUM OF VICTORIA RUSSELL ST., MELBOURNE, VIC. 3000	1967
SOMERSET, SIR HENRY, MSC MAIMM C/- A.P.P.M. LTD., 360 COLLINS ST., MELBOURNE, VIC. 3000	1957
SOUTHBY, DR. R. MD FRACP FACST 43 HAINES ST., NORTH MELBOURNE, VIC. 3051	1965
SPEARS B.F. 49 MENIN ROAD FOREST HILLS VIC 3131	1968
SPECHT, PROF.R.L. MSC PHD BOTANY DEPT., QLD. UNI., ST. LUCIA, BRISBANE, QLD. 4067	1961
SPENCER L.B. 13/17 ROCKLEY ROAD SOUTH YARRA VIC 3141	1968
SPENCER-JONES, DR. D. BSC PHD 31 WIMMALEE RD., BALWYN, VIC. 3103	1952
STAFF, DR. I.A. MSC DIPED SYD SCHOOL BIOL. SCIENCES, LA TROBE UNI., BUNDOORA, VIC. 3083	1967
STELLA A.R. BARCH ARIBA 6 ARGYLE PLACE NORTH CARLTON VIC 3053	1968
STEWART, A.J. MSC GEOLOGY DEPT., YALE UNI. NEW HAVEN, CONNECTICUT, U.S.A.	1961
STEVENS, B.J.M. 6 JENNINGS ST., SANDRINGHAM, VIC. 3191	1961
STRAUSS, DR. W. 9 MOORE ST., HAWTHORN, VIC. 3122	1968
STREET, PROF. R. MA PHD LOND 17 HOWIE ST., GLEN IRIS, VIC. 3146	1965
STRUSZ, DR.D.L. BSC PHD 97 BURNIE ST., LYONS, A.C.T. 2606	1966
STYLES, D.F. BSC AMIE AUST 14 JOHN ST., BLACKBURN, VIC. 3130	1958
SULLIVAN, W. 37 STRATHALLAN RD., MACLEOD, VIC. 3085	1943

SUTTON, DR. P.R.N. DDSC LDS 24 WELLINGTON ST., BRIGHTON, VIC. 3186	1959
SWAN J.M. PHD DSC FAA FRACI 28 THE RIDGE CANTERBURY VIC 3126	1968
TAFT B. MB BS DDR MCRA 166 RIVERSDALE ROAD CAMBERWELL VIC 3124	1968
TATTAM DR.C.M. PHD DSC 7 ALBERT JONES COURT EAGLEMONT VIC 3084	1945
TAYLOR, D.J. MSC 23 WESTBOURNE ST., PRAHRAN EAST, VIC. 3181	1961
TAYLOR J.I. DIP ARCH ARIBA 5 HIGH ST BEAUMARIS VIC 3193	1968
TEMPLE, P. 7 MONASH ST., ASCOT VALE, VIC. 3032	1962
TENNI P.B. BSC AMIIE 641 CANTERBURY ROAD VERMONT VIC 3133	1968
TERNOUTH, S.T. BSC DIPED 5 KANOOKA AVE., LOWER TEMPLESTOWE, VIC. 3107	1957
TEX, PROF. E. DEN PHD LEYDEN % GEOL. MIN. INST. R.U.V., LEIDEN ST. U.,GARENMARKT IB LEYDEN, HOLLAND	1952
THOMAS, H.F. P.O. BOX 78, IRYMPLE, VIC. 3498	1961
THOMAS, DR. G.A. BSC PHD GEOLOGY DEPT., MELB. UNIVERSITY, PARKVILLE,VIC. 3052	1944
THOMAS, F.J.D. BSC HONS ARCS % I.C.I.A.N.Z. BIOL. RESEARCH STN., CROYDONVIC. 3136	1955
THORN, W. MEE MIE AUST 9 FLORENCE AVE., KEW, VIC. 3101	1958
THOMSON MISS F.E. BA ALAA FLAT 3 24 MASON STREET HAWTHORN VIC 3122	1968
THOMSON DR J.A. MSC PHD GENTICS DEPT., MELB. UNI., PARKVILLE, VIC. 3052	1958
THOMSON PROF.D.F OBE DSC MELB PHD CANTAB DIPANTH DEPT. OF ANTHROPOLOGY, MELBOURNE UNI. PARKVILLE, VIC 3052	1958
THOMPSON, G.T. UNIT 8, MARANOA COURT, 8 PARRING RD., BALWYN VIC. 3103	1953
THOMPSON, G.D. AMIE AUST HONMIBF LOND ROYAL MELB. INST. OF TECHNOLLATROBE ST., MELBOURNE, VIC. 3000	1959
THOMPSON B. BSC MINES DEPT. TREASURY PL., MELB., VIC. 3002	1963
TIMCKE, E.W. 15 FAIRCROFT AVE., GLEN IRIS, VIC. 3146	1950
TOWNSEND, PROF. S.L. MD MS FRCS(EDTN) UNIVERSITY OF MELBOURNE, PARKVILLE, VIC. 3052	1957
TURNER, PROF. J.S. MA PHD MSC FAA BOTANY DEPT. MELBOURNE UNI. PARKVILLE, VIC. 3052	1938
TYLEE, A.N. SIMSONS RD., LARDNER, VIA WARRAGUL, VIC. 3821	1951
UHL, A.H. MIE AUST MIEE LOND MAIEE NY 1 GWENDA AVE., BLACKBURN, VIC. 3130	1964
VALE, W.H. 17 WALSTAB ST., EAST BRIGHTON, VIC. 3187	1961
VAUGHAN G.N. BSC COLLEGE OF PHARMACY ROYAL PARADE PARKVILLE VIC 3052	1968
VERSO, DR. M.L. MB BS DTM&H MCPA BLOOD BANK, 114 FLINDERS ST., MELBOURNE,VIC. 3000	1962
WADHAM, PROF. SIR SAMUEL MA LLD ACRDIP 220 PARK ST., WEST BRUNSWICK VIC 3055	1932
WAKEFIELD, N.A. BSC 30 DOUGLAS ST., NOBLE PARK VIC 3174	1961
WALDMAN, M. MSC DEPT. ZOOL. COMP. PHYSIOL., MONASH UNIVERSITY, CLAYTON, VIC. 3168	1966
WALSH, R.W. BA 896 SWANSTON ST., CARLTON, VIC. 3053	1964
WARDROP, PROF. A.B. MSC(TAS) PHDLEEDS DSC MELB 3 GWENDA AVE., BLACKBURN, VIC. 3130	1968
WARK, DR.J.MCF. CBE DDSC 117 YARRANBAT AVENUE, BALWYN, VIC. 3013	1966
WARK, DR.I.W. CBE PHD DSC FAA DEPT. EDUCATION AND SCIENCE,99 QUEEN ST., MELBOURNE, VIC. 3000	1961

WARNEKE R.M. BAGRSC MSC FISH.&WILD.DEP.605FLINDERSSTMELBOURNE VIC 3000	1967
WARREN, PROF.J.W. MA PHD ZOOLOGY DEPARTMENT, MONASH UNIVERSITY, CLAYTON, VIC. 3168	1963
WARREN, G. 9 MARILYN COURT, WATSONIA, VIC. 3087	1968
WATKINS, R.D. BAPPLSC LOSC PHYSICS DEPARTMENT, IMPERIAL COLLEGE, LONDON,SW7ENGLAND.	1967
WATSON, MRS. J. ASMB AMTC 74 NIMMO ST., ESSENDON, VIC. 3040	1961
WATSON, G.F. ZOOLOGY DEPARTMENT, MELB. UNIVERSITY, PARKVILLE,VIC. 3052	1968
WEBB G C BSC DIPED 47 FORTUNA AVE NORTH BALWYN VIC 3104	1968
WEICKHARDT, L.W. MSC FRACI 125 CANTERBURY RD., CANTERBURY, VIC. 3126	1959
WELLS, DR. R.J.H. BVSC PHD CANTAB ''MADINGLEY'', STATION RD., MELTON, VIC. 3337	1965
WEST, A.L. BA DIPSOCSTUD 17 THE RIDGE, KNOXFIELD, VIC. 3180	1967
WESTE MRS. G. MSC 29 GILBERT GROVE BENTLEIGH VIC 3204	1968
WETTENHALL, DR. H.N.B. MD BS MRCP FRACP 41 SPRING ST., MELBOURNE, VIC. 3000	1959
WHARTON, J.C.F. BSC 10 RAYMOND ST., ASHWOOD, VIC. 3147	1967
WHITBY L.R. AASA ACIS 55 WINGATE STREET BENTLEIGH EAST VIC 3165	1968
WHITE, PROF. M.J.D. DSC LOND FRS FAA GENETICS DEPARTMENT, MELB. UNIVERSITY, PARKVILLE,VIC. 3052	1958
WHITELAW, J.J. BME 286 HUNTINGDALE RD., CHADSTONE, VIC. 3148	1963
WHITE, R.K. FIPAA 414 COLLINS ST., MELBOURNE, VIC. 3000	1958
WHITER R.H. 13 ANDERSONS RD EAST HAWTHORN VIC 3123	1967
WHITING R.G. BMECHE 3 PARKSIDE AVE BALWYN VIC 3103	1959
WILCOCK, A.A. BSC BED GEOGRAPHY DEPARTMENT, MELB. UNIVERSITY, PARKVILLE,VIC. 3052	1934
WILKINSON H.E. B SC NATIONAL MUSEUM RUSSELL ST MELBOURNE VIC 3000	1963
WILLIAMS C.M. AASA 4 OLINDA AVENUE, BEAUMARIS VIC. 3191	1968
WILLIS, A.G. MSC ZOOLOGY DEPARTMENT, MELB. UNIVERSITY, PARKVILLE,VIC. 3052	1949
WILLIS J.H. BSC 102 MALE ST BRIGHTON VIC 3186	1964
WILSON, D. BSC 46 HODDLE ST., ESSENDON, VIC. 3040	1961
WILTSHIRE, A.R.L. CMG DSO MC VD FLAT 9, 424 GLENFERRIE RD., KOOYONG, VIC. 3144	1955
WONG N. MSC GEOLOGICAL SURVEY OFFICE KOTA KINABALU MALAYSIA	1968
WOODFORD, E.R. 40 ROSE ST., MCKINNON VIC. 3204	1963
WOODRUFF, D.S. BSC TRINITY COLLEGE, PARKVILLE, VIC. 3052	1965

ASSOCIATES

ANDERSON, R.E. BA 20 HUDSON STREET MOONEE PONDS VIC. 3039	1964
AUTRY W.C. BSC P.O. BOX 58354 HOUSTON TEXAS U.S.A. 77058	1957
BAKER A.A. P.O. BOX 164, MORNINGTON, VIC. 3931	1946
BALDWIN J.G. BSC BAGRSC 33 WALNUT AVE., MILDURA VIC. 3500	1949

BAMFORD, W.E. BE(HONS) 352 DANKS STREET, MIDDLE PARK VIC, 3206	1963
BAUM F.T. 1 BERYL ST., NUNAWADING, VIC. 3131	1967
BEAVIS MRS. J.H. P.O. BOX 67, CLAYTON VIC 3168	1965
BELL G 62 RUSSELL ST SURREY HILLS VIC 3127	1955
BIRD, R.G. 112 PRINCE ALFRED PARADE NEWPORT, N.S.W. 2106	1962
BISHOP J.J. BA HIGH SCHOOL MOE, VIC 3825	1950
BOCH P.E. BSC 32 SWAYSFIELD RD., MT. WAVERLEY, VIC 3149	1957
BOLLEN P.W. 5 MERCER RD., ARMADALE, VIC 3143	1957
BOURKE D.O.N. 141 SOUTH RD., BRIGHTON, VIC. 3186	1964
BOWEN K.G. BSC 2 BURKE ST,, MONTMORENCY, VIC. 3094	1966
BOWLER J.M. MSC INST.OF ADVANCED STUDIES A.N.U. CANBERRA ACT 2600	1960
BRINE F. W. 'TAUNTON' OAKDENE COURT MT.WAVERLEY VIC 3149	1964
BURN R. 3 NANTES ST. NEWTOWN GEELONG 3220	1956
BURNS D. S. 11 ROBERTSON ST. COLAC VIC 3250	1960
BUTTERY S. H. 146 HIGHFIELD RD. CAMBERWELL, VIC 3124	1952
CARR MRS. D. J. MSC BIOL.SCI.RESEARCH SCHOOL ANUP.O.BOX4, CANBERRA ACT. 2600	1937
CARTER A.E. 12 BERTRAM ST. BURWOOD VIC 3125	1968
CARTER DR. A. N MSC PHD 8 SCOTT ST. MAROUBRA NSW 2035	1947
CLARKE W. G. BE BSC DIPED 2 MEEK CRESCENT FAULCONBRIDGE NSW 2776	1957
CLIFFORD DR.H. T. MSC PHD BOTANY DEPT. QUEENSLAND UNI.ST.LUCIA QLD. 4067	1949
COBBETT A. M. 4 OXFORD CLOSE MOORABBIN VIC. 3189	1951
COCHRANE G.W. MSC 320 LANE ST. BROKEN HILL NSW 2880	1945
COLLEDGE MISS J.S. 51 THROUGH RD. BURWOOD, VIC, 3125	1964
CORMACK, M.G. LWR. CRAWFORD PTE. BAG 39, HEYWOOD, VIC. 3304	1961
COUPER, JAMES K. FRMIT % R.HARE & ASSOCIATES 18 LITTLE COLLINS ST., VIC. 3000	1965
COURT, A.B. BSC NATIONAL HERBARIUM SOUTH YARRA, VIC. 3141	1949
COVENTRY, A.J. NATIONAL MUSEUM OF VICTORIA,RUSSELL ST. MELBOURNE. VIC 3000	1966
DAVIES, A.F. WAYSIDE DEL BRIDGEWATER RD..PORTLAND, VIC. 3305	1965
DE JONK, B.T.R. 21 MALL COURT, BLACKBURN VIC. 3130	1964
DICKINS DR. J. MCG. MSC.PHD. BUREAU OF MINERAL RESOURCES,CANBERRA, A.C.T. 2600	1952
ELFORD, F.G. BSC BED 76 NEW ST., BRIGHTON, VIC. 3186	1929
ELMORE, L.K.M. P.O. BOX 317 HAMILTON, VIC. 3300	1964
ENGLISH, J.R. 302 LOWER HEIDELBERG RD., EAST IVANHOE, VIC. 3079	1956
EVANS, W.P. 8 ANZAC CRESCENT, WILLIAMSTOWN. VIC. 3016	1968
FINLAY MISS C.J BSC GEOLOGY DEPT,MELBOURNE UNIVEPARKVILLE VIC 3052	1958
FISHER, DR. EILEEN E. PHD 1 BALWYN RD., CANTERBURY, VIC. 3126	1949
FORREST, J.M. METROPOLITAN FARM, WERRIBEE VIC 3030	1954
FROSTICK, A.C. 12 POWER ST., NORTH WILLIAMSTOWN, VIC. 3016	1933
GAMBLE, D.S. 6 GELLIBRAND ST., KEW, VIC. 3101	1964

GLAESSNER, DR. M.F. PHD DSC FAA DEPT. OF GEOLOGY, ADELAIDE UNIVERSITY, S.A. 5000	1939
GOSTIN, V.A. BSC MSC DEPT. OF GEOLOGY , A.N.U., CANBERRA. A.C.T 2600	1963
HATTON, H. 55 HUNT CRESCENT, ASCOT VALE, VIC. 3032	1965
HILL, DR. D. DSC PHD FAA UNIVERSITY OF QUEENSLAND, ST.LUCIA QLD 4067	1939
HOUNSLOW, A.W. BSC 28 GEORGIANA ST., SANDRINGHAM, VIC. 3191	1958
KENLEY, P.R. BSC 14 YARRABEE COURT, MT. WAVERLEY, VIC. 3149	1948
KERSHAW R.C. BSC 45 WEST TAMAR RD., LAUNCESTON, TAS. 7250	1956
LAWRENCE, C.R. BSC 4 UNA ST., MT.WAVERLEY. VIC. 3149	1958
LEARMONTH, A.P. 12 CORNWALL RD., SUNSHINE, VIC. 3020	1955
LINDHOLM, J.D.E. P.O. BOX.180, HEYWOOD, 3304	1952
LORD, E.E. 16 SALISBURY COURT, HEATHMONT, VIC. 3135	1950
MARSDEN, M.A.H. BSC DEPT OF GEOL MELB.UNIV., PARKVILLE, VIC. 3052	1952
MATTHAEI MRS.G BA DIPED 146 GATEHOUSE ST PARKVILLE VIC 3052	1959
MCLAURIN, A.N. COUANGALT, VIA GISBORNE VIC. 3437	1963
MCLENNAN, PROF. E. DSC BOT DEPT UNIV OF MELB., PARKVILLE, VIC. 3052	1915
MOONEY, M.J. 'BEANN NHAIRI', YARRA JUNCTION, VIC. OM.M	1963
MOORS, H.T. BSC FLAT2, 41 ALFRED CRESCENT, NORTH FITZROY, VIC. 3068	1965
NEILSON, J.L. BSC 55 GLYNDON RD., CAMBERWELL, VIC. 3124	1952
NETHERWAY G.C. 606 DANA ST., BALLARAT, VIC. 3350	1958
NICHOLSON B.M. BAGRSC SOIL CONSERVATION AUTHORITY,P.O. BOX 187 BAIRNSDALE, VIC. 3875	1963
NIKSIC N. ARACI, DIPENG ZAGREB 5 VAUGHAN AVE., CANTERBURY, VIC 3126	1966
PASSIOURA, DR. J.B. CSIRO, DIV. OF LAND RESEARCHP.O. BOX 109 CANBERRA A.C.T. 2601	1961
PATON R.J 295 DORSET RD BORONIA VIC 3155	1968
PAYNE T.E.N. WOODBURN, KILMORE, VIC. 3601	1945
PICKEN I.D. 20 PACKINGTON ST., KEW, VIC. 3101	1967
PINCHES MRS. M. 140 CHURCHILL HIGHWAY, BRAYBROOK, VIC. 3019	1943
POOLE I.R. 27 GLEN EBOR AVE., BLACKBURN, VIC. 3130	1966
PRETTY R.B. BSC PRIVATE MAIL BAG, COBARGO, N.S.W. 2547	1922
RASH, K.E. 159 HUMFFRAY ST., BALLARAT, VIC. 3350	1960
RAWLINS R.J. BSC P.O. BOX 2, HERBERTON, QLD. 4870	1957
REED K.J. BSC % NIGERIAN GULF OIL CO., P.M.B. 2469 LAGOS, NIGERIA.	1958
RIMINGTON K.N. BSC. 12 STAWELL ST., BEAUMARIS, VIC. 3193	1948
ROWE R.K. BSC. FOR. 17 BRODY ST. WANGARATTA, VIC. 3677	1965
SEARLE S.S. METROPOLITAN FARM WERRIBEE, VIC. 3030	1954
SEEBECK J.H. BSC FLAT 1, 23 HAINES ST. HAWTHORN. VIC. 3122	1967
SHAW H. 16 DOUGLAS AVE. BOX HILL SOUTH VIC. 3128	1956
SHERRARD MRS. H.M MSC 43 ROBERTSON RD., CENTENNIAL PARK, SYDNEY, N.S.W 2021	1918
SIMPSON B. 3 KNUTSFORD ST., BALWYN, VIC. 3103	1959
SIMPSON K G. 27 KINGSWOOD DRIVE DINGLEY VIC 3172	1967
SINNOTT P.J. 17 NORMDALE RD., EAST BENTLEIGH, VIC. 3165	1959

SPRY MISS ELAINE M. BSC. MONASH TEACHERS COLLEGE NORTH CLAYTON. VIC. 3168	1966
STONE DR. I.G. MSC. PHD. 24 ALANDALE RD., EAGLEMONT, VIC 3084	1965
STONE, A.G. 24 ALANDALE RD., EAGLEMONT, VIC. 3084	1965
STUBBS D. 2 COLERIDGE ST., ELWOOD, VIC. 3184	1960
TAYLOR T.W. BOX7 CLONCURRY QUEENSLAND 4824	1963
TUDDENHAM W.G. BSC DIPED GEOGRAPHY DEPARTMENT, SYDNEY UNIVERSITY,SYDNEY N.S.W. 2006	1963
VANDENBERG A.H.M. 6 FREW AVE., FRANKSTON, VIC. 3199	1965
VASEY MRS.F.R BSC MELBOURNE PUCKS HOLLOW FERNY CREEK VIC 3786	1968
VASEY G.H. BCE MELBOURNE UNIVERSITY PARKVILLE, VIC 3052	1936
WALKER DR. A.L. MINERAL CHEM. DIV. CSIRO SALMON ST., GARDEN CITY VIC. 3207	1961
WATTS H.A. 15 TOWER HILL RD GLEN IRIS VIC 3146	1954
WHITEHEAD MRS. R. MSC C/O ANACONDA AUST. INC. 208 HUTT ST., ADELAIDE, S.A. 5000	1942
WHITE O.L. BSC MASC CIVIL ENG DEPT WATERLOO UNI.WATERLOO, ONTARIO, CANADA.	1955
WILKINS DR.R.W.T. MSC PHD DEPT OF GEOLOGY UNIV OF QUEENSLAND ST LUCIA QLD 4067	1961
WILLIAMS MRS.J.F.H 8 MONTAGUE ST HIGHTON VIC 3216	1962
WILLIAMS G.E. M.SC DEPT.OF GEOLOGY THE UNIVERSITY OF ADELAIDE S.A. 5000	1962
WYMOND A.P. MSC % DIV. FOREST PRODUCTS CSIROP.O.BOX 18 SOUTH MELBOURNE VIC. 3205	1951
YATES H. MSC 102 EYRE ST., BALLARAT, VIC. 3350	1943
JOHNS DR. M. W. MB BS BSC, 12 ELLISON ST., E. MALVERN, VIC. 3145	1958
JONES B. C. MA LLB ACTT, 24 PURDY AVE., DANDENONG, VIC. 3175	1965

Royal Society of Victoria

REPORT OF THE COUNCIL FOR THE YEAR ENDING 13 MARCH 1969

The Council presents to Members of the Royal Society of Victoria the report of its work and on the various activities of the Society during its 114th year.

The Society, which is the State's oldest learned Society, has as its aim the advancement of science. In addition to the encouragement of research on our local environment through publications and symposia and by the maintenance of a Library, the Society aims to promote the integration of findings from the various disciplines of science and to interpret their significance in the life of the community for the benefit of non-scientists in other professions and walks of life; to provide a forum where questions of public importance can be debated; and to create an influential body of opinion on matters of national scientific importance.

Significant increases in membership, a much improved financial situation, and the appointment of an Executive Officer during the year will allow the Society to give more effective consideration to implementing these aims in the future.

COUNCIL—The following Office-bearers and Councillors were elected at the Annual General Meeting on 14th March 1968 and managed the affairs of the Society.

President: Dr P. G. Law

Vice-Presidents: Mr A. Dunbavin Butcher, Professor C. M. Tattam

Immediate Past President: Mr J. H. Chinner

Hon. Treasurer: Professor J. D. Morrison

Hon. Librarian: Professor C. M. Tattam

Hon. Secretary: Mr D. S. Woodruff

Hon. Editor: Professor G. W. Leeper

Hon. Assistant Secretary: Mr G. A. Kaufmann

Hon. Research Secretary: Mr. E. D. Gill

Hon. Development Manager: Dr G. A. Sklovsky

Mr L. Adams
Mr V. G. Anderson
Mr H. C. Chipman
Dr B. D. Cuming
Dr R. R. Garran
Mr A. E. Perriman
Dr C. E. Resch
Professor G. C. Schofield
Dr D. Spencer-Jones
Professor P. J. Fensham

The resignations of Professor J. A. Andrews from Council at the end of 1967, and of Dr C. H. Resch and Professor C. M. Tattam at the end of 1968 were accepted with regret and minutes of appreciation were recorded.

Council met eleven times during the year and the attendance of members was excellent.

COMMITTEES OF COUNCIL. The following Committees, formed to assist Council, met during the year: House, Publications, Programme, Development, Membership, Library, Education. The Education Committee was established during the year to study proposals for Society activities in the field of education.

MEETINGS AND LECTURES. During the year, ten Ordinary and three Special Meetings were held.

MARCH 14—'The Planned Utilization of the Natural Resources of Victoria' by Mr R. G. Downes and Mr A. Dunbavin Butcher.

APRIL 18—'The Amery Ice Shelf Project', by Mr W. Budd.

MAY 9—'The Application of Science and Research to the Design of the Victorian Arts Centre', by Sir Roy Grounds.

JUNE 13—Symposium: 'The Aquatic Environment and Man', in collaboration with the Australian Society for Limnology and the Australian Water and Wastewater Association. The Symposium was opened by Mr L. W. Weickhardt, and the Chairmen of sessions were Mr H. G. Furphy, Dr I. D. Hiscock and Dr P. G. Law. Speakers were Mr C. D. Parker, Dr I. A. E. Bayly, Dr W. D. Williams, Mr R. A. Horsfall, Mr B. J. Callinan, Mr K. R. Garland and Mr J. C. Wharton.

JULY 11 and 25 (Special) and AUGUST 8—Seminar: 'Your Child and its Future'.

JULY 11—'Education for a Technological Age'. Speakers: Dr D. M. Myers and Mr J. R. Pascoe.

JULY 25—'Man's Mechanical Mind—Computers'. Speakers: Mr E. A. Mayer and Mr. H. J. Halstead.

AUGUST 8—'The Destiny of Man'. Speakers: Professor Sir Macfarlane Burnet and the Rev. Dr J. D. McCaughey.

SEPTEMBER 5 (Special)—'Science, Education and Government', by Professor F. S. Dainton.

SEPTEMBER 17—Public Lecture in association with the University of Melbourne Extension Committee. 'The Present Status of the Theory of Evolution', by Professor G. G. Simpson.

OCTOBER 10—'Feeding the Hungry World' by Dr F. W. Clements.

NOVEMBER 14—Soirce: Illustrated Lecture by Mr R. E. Rotherham, *Victorian Wildflowers*. Exhibits by A. H. Reed (Publishers) and by H. Levinson, Pty. Ltd. (Photographic equipment).

DECEMBER 12—Research Papers. 'Ecology of Western District Saline Lakes', by S. U. Hussainy, 'Evolutionary Trends in Graptolites', by H. T. Moors, and 'Pollen Deposition at Wilson's Promontory', by G. S. Hope.

The seminar, 'Your Child and Its Future', was presented in conjunction with the Australian Broadcasting Commission. Recordings of lectures and subsequent discussions thus reached a very wide audience. Copies of lectures are available. The papers delivered at the symposium will be published in 1969.

Attendances for 1968 totalled about 900 as against 510 in 1966 and 730 in 1967. A further 600 attended the Public Lecture. This support is encouraging and Council trusts the programme for 1969 will prove equally interesting.

MEMBERSHIP—During the year, 81 new members and associates were elected and 5 resignations accepted. The number of members at 12 February, 1969 was:

Honorary 2, Life 19, Members 434, Country 14 (this category of membership has been closed) and Associates 87. Council decided that in future, except in special circumstances, only students and Members' spouses could qualify for Associate Membership.

During the year the Society has been transferring its membership records to a computer. This system should become effective later this year.

The Society deeply regrets the death, during the year, of the following member:

JAMES SMITH REID was born at Silverton on 5 September 1886 and died at Somers on 21 April 1967. He was educated at St Peter's College, Adelaide and later at Trinity College, Cambridge, where he completed the Natural Philosophy Tripos with first-class honours in 1908. He worked in England with Chance Brothers on nitrogen fixation, and on returning to Australia after the war he joined the technical staff of Dunlop Rubber Australia, where he became Chief Chemist. He was a member of the Royal Society of Victoria from 1920, and a life member from 1951.

LAWS—During the year Law 44 (Authors' Copies) was amended, reducing from 50 to 25 the number of free authors' reprints.

TRUSTEES—The resignation of Sir Arthur Dean as a Trustee of the Society was accepted with regret and Council places on record its gratitude to Sir Arthur for his long and valuable service. Mr Justice Menhennitt has been appointed to the vacancy.

PROCEEDINGS—During the year the Society published Volume 81 (parts 1 and 2) of *Proceedings*. The cost of this activity ($6,650) was borne in part by donations and Council acknowledges with gratitude the assistance received from the University of New England, the University of Queensland and the University of Melbourne.

The length of manuscripts continues to be an editorial problem and changes have been made to the Instructions to Authors and Referees. Changes have also been made to the jacket and front cover design of *Proceedings*. Following a delay in plate production last year, efforts are being made to decrease the time between acceptance of a paper and its publication. Council places on record its gratitude to Professor G. W. Leeper, the retiring Editor, and to Mrs Grace Matthaei, the Assistant Editor.

LIBRARY—2736 volumes and parts were added to the Library during the year, mostly from exchange with 336 Australian and foreign organizations. 475 items were borrowed from the Library (446 in 1967). Council is grateful to A. N. and A. W. Reed for the gift of a copy of *Flowers and Plants of Victoria*. Council records its gratitude to Professor C. M. Tattam, retiring Honorary Librarian, and to Mr R. E. Anderson, Assistant Librarian.

HALL—In addition to the Society and the Royal College of Obstetricians and Gynaecologists, 33 professional and other bodies held 122 meetings on the premises, compared with 296 in 1967. This decrease is due in part to the movement of several groups to the National Science Centre. Rentals for the Hall have been increased, and efforts are being made to attract new tenants. Repairs and improvements costing $1,420 were carried out during the year. Cracks in the building, which appeared during the drought of 1968, are being investigated, and minor alterations to the Library, Kitchen, Supper Room and Office have been authorized.

Maintenance costing $350 was necessary for the water mains to the 99-year-old Cottage during 1968.

ADMINISTRATION—During the year the Secretary and Assistant Secretary were assisted by Mrs. Frances Boyd and, later, by Miss Anna Foo and Miss Deidre Walker. Council expresses its gratitude for their work. The nature and volume of work entailed in the Society's activities have made it necessary to appoint an Executive Officer to oversee the Society's affairs. Council has appointed Dr R. R. Garran to this position.

FINANCIAL STATEMENT—It has become increasingly difficult for the Society to balance expenditure and income. The cost of publishing *Proceedings* has risen steadily over the years, due partly to increases in production costs, but more to the larger number of papers selected for publication. A substantial portion of the Society's income arises from grants towards the publication costs of individual papers and from the sale of publications.

The State Government has increased its grant to the Society from $1,600 to $3,600 per annum, and this assistance is very much appreciated.

During the year membership subscriptions were increased to $10 per annum for Members and $8 per annum for Associates. This, together with increased membership, has led to greater income from this source.

The Skeats Bequest has made a great improvement in the Society's financial situation. The capital is invested, and part of the income will be devoted to the provision of an adequate sinking fund for the maintenance of the buildings and furnishings. The Bequest included $5,783 cash and securities valued at $43,510 in December 1967 (the date of distribution), a total of $49,293. Present market value (26th February 1969) of the securities is $49,785, and the annual return on the total bequest is about $1,800. It is hoped that this return will be increased by judicious reinvestment.

INSTITUTE OF MARINE SCIENCE—The Council of the Society, in collaboration with Melbourne, Monash and La Trobe Universities and the Victoria Institute of Colleges, has been investigating a proposal to establish an Institute of Marine Science with facilities for research and teaching.

RESEARCH MEDAL—The Society's Research Medal for 1967 was awarded to Mr E. D. Gill, Assistant Director of the National Museum of Victoria. The medal was presented on 8 August 1968 by Sir Macfarlane Burnet. The 1968 Award Committee selected Dr Alan Walsh, Assistant Chief, Division of Chemical Physics, CSIRO, and the presentation will be made during 1969.

Many people have assisted the Society during the year and Council, on behalf of the Society, wishes in particular to thank the following individuals and organizations: Sir Ian Potter (Hon. Financial Adviser), Sir Roy Grounds and Mr F. Suendermann (Hon. Architects), Phillips, Fox and Masel (Hon. Solicitors), the Parks and Gardens Department of the Melbourne City Council, Miss Jean Colledge, Miss Elaine Spry, Mrs M. Davies, Dr Lance Finch, Mr H. P. Simpson, Mr R. C. Seeger, and Mr and Mrs A. Sadik.

This Annual Report has been adopted by Council for presentation to the Annual General Meeting on 13 March 1969.

P. G. LAW,
President

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST DECEMBER 1968

RECEIPTS		
Cash at Bank 1.1.68		$989.49
Benefactions		5783.47
Grants and Donations:		
University of New England	$211.75	
University of Queensland	130.00	
State Treasury	5200.00	
Miscellaneous	40.00	
		5581.75
Interest:		
Benefactions	2105.00	
Investments	1578.43	
Bank	38.70	
		3722.13
Miscellaneous Refunds		42.86
Rent		2538.02
Subscriptions		3763.84
		$22421.56

PAYMENTS		
Electricity		$841.50
Hallkeeping	$435.60	
Less Hallkeeping refund	343.76	
		91.84
Insurance		117.84
Meeting Expenses		579.00
Postage		343.35
Publishing of Proceedings	6247.77	
Less Sale of Publications	1356.12	
		4891.65
Rates and Taxes		48.80
Repairs and Maintenance		1274.71
Stationery		565.13
Sundry Expenses		22.12
Salaries:		
Assistant Librarian	357.00	
Assistant to Hon. Secretary	1210.90	
Assistant to Editor	400.00	
		1967.90
Telephone		179.74
Cash at Bank 31.12.68		11497.98
		$22421.56

(Signed) JAMES D. MORRISON,
Hon. Treasurer

I report that I have conducted an audit of the cash transactions of the Royal Society of Victoria for the twelve months ended 31st December 1968, and in my opinion the attached Statement of Receipts and Payments exhibits a true and fair view of the Society's cash position as at 31st December 1968. The Society does not keep any Registers of Securities or Investments and no Statement of Assets and Liabilities has been prepared.

Melbourne, 13th March 1969

(Signed) T. C. BOEHME, F.C.A., *Hon. Auditor*

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ERRATA

VOL. 81 **PT.** 2 p. 144. Insert under *TABLE 1. Analysis of Spring Waters.* Values for Nos. 2 & 3 lie mid-way between 1 & 4. Values for 10 & 11 are similar to No. 8. This data has been omitted from the table to conserve space. All values given are in parts per million. The following elements were estimated with the limits of detection shown in brackets. Unless otherwise stated all are below sensitivity. Cr (0·2); Co (0·2); Ni (0·2); Cu (0·1); trace in Nos. 1, 4, 20, 21; Zn (0·05), No. 6 = 0·21; Ag (0·1); Cd (0·05); Ba (10); Au (0·3); Pb (0·5) trace in No. 16.

VOL. 82 **PT.** 1 p. 5, line 10. 1899 should read 1889. Page numbered 75 should precede page numbered 74. pp. 77-103, 'Census of Vascular Flora Indigenous to East Gippsland', by J. H. Willis. The author now requests that corrections to his earlier spelling be noted as follow: p. 79, *Festuca hookeriana* read *hookerana*; p. 80, *Agrostis muelleriana* read *muellerana*; p. 81, *Gahnia sieberiana* read *sieberana*; p. 88, *Hedycarya augustifolia* read *angustifolia*, *Cardamine distyosperma* read *dictyosperma*, *Crassula sieberiana* read *sieberana*; p. 92, *Pomaderris sieberiana* read *sieberana*, *Pomaderris feruginea* read *ferruginea*; p. 93, *Viola sieberiana* read *sieberana*; p. 96, *Sesseli* read *Seseli*.