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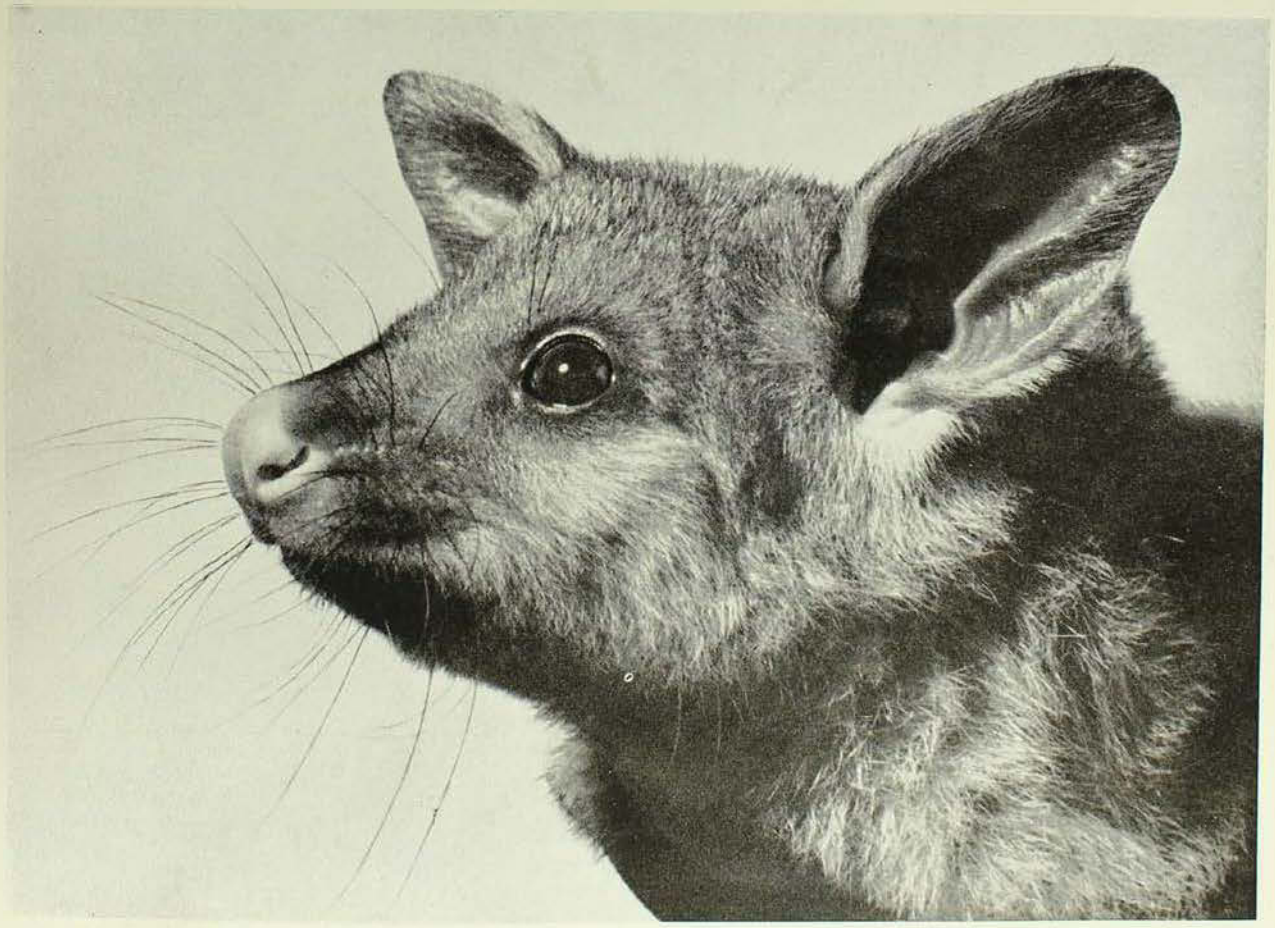

Brush-tailed Possum about 4½ months old. **(See article, "Australian Mammals", Page 121)**

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THE AUSTRALIAN MUSEUM

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THE AUSTRALIAN MUSEUM MAGAZINE

(Photography, unless otherwise stated, is by Howard Hughes, A.R.P.S.)

OUR FRONT COVER.—The brush-tailed possum (*Trichosurus vulpecula*) is one of the largest and commonest of the phalangers, known as "opossums" in Australia. The true opossums, found only in America, belong to a different family of marsupials. The phalangers, which have prehensile limbs and usually a prehensile tail, are all expert climbers. Unless disturbed, they are seldom seen in the daylight. The main breeding period of the brush-tailed possum appears to be in the autumn although spring births are not uncommon. Usually, only one young is born at a time and it is carried in the mother's pouch for 4 to 5 months. (See article, Page 121.)

Vol. XII, No. 4 DECEMBER 15, 1956

IN an endeavour to increase the interest of this Magazine a small planning Committee consisting of the Director of the Museum, the Editorial Assistant and the Acting Curator of Birds, has been set up. Three of the decisions of the Committee have been to seek more articles from outside contributors than has been customary in the past; to include articles on plant life and to publish each December an issue which should deal with some special topic in an authoritative fashion. The last (September) issue was the first to have been planned by the Committee and the December number is the first "special" issue.

The subject chosen has been Australia and while limitation of space has prevented the treatment being as comprehensive as is desirable it is hoped, nevertheless, that readers will find the articles of interest and welcome this new departure.

THE EDITOR

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VOLUME XII, NUMBER 4 DECEMBER 15, 1956

The Ancient Seas of Australia

By CHARLES F. LASERON

SINCE the dawn of geological history the sea has at least nine times covered different parts of Australia. The number is probably greater than this, for the evidence of what happened in the earliest times is often fragmentary and confusing, and it is difficult to trace the full extent of the many geographical changes which undoubtedly took place.

The up and down movements of the earth's crust which submerge part of the land beneath the sea or elevate the sea bed to dry land, as well as lateral thrusts which fold and twist the rocks into high mountain ranges, have been going on throughout geological time; so also have the forces of erosion again and again worn away the highest mountains. To human conception these events seem on a tremendous scale—actually, compared to the bulk of the earth, they are almost insignificant. If a model globe of the world were made with a diameter of 20 feet, Mt. Everest to scale would be a faint pucker one-seventh of an inch high, and the greatest depth of the ocean would be a mere one-fifth of an inch. The Tasman Sea would be one-ninth of an inch deep. Mt. Kosciusko would rise above the general level by one-thirtieth of an inch, and a subsidence of one-ninetieth of an inch would submerge the greater part of Australia below the ocean. It is no wonder then that these relatively slight movements of the earth's crust throughout the ages have caused many geographical changes, and that the sea has spilled over the land on so many occasions.

The first sea of which we have reasonable cognizance in Australia may be termed the Proterozoic Sea, for it covered part of the continent in the Proterozoic Era, from about 1000 to 600 million years ago. There were earlier seas, but their boundaries have been obscured by time, and their extent and succession are largely conjectural. In the vast period of its duration the Proterozoic Sea probably advanced and receded many times, but we do know that at an early stage Australia was divided into several islands, one covering part of Western Australia, another in the vicinity of the Kimberleys, another a large part of eastern Australia. As far as is known it was nearly a dead sea, for no undoubted fossils have been found in the rocks deposited, but there were probably seaweeds in the shallows near the shore, and possibly the ancestral forms of many sea animals as well. One interesting fact is also known, that the climate in the Proterozoic Era fluctuated within much the same limits as it does now, and there has been no general

chilling of the earth as at one time was thought. Twice during the later part of the Era there were glacial periods when great ice sheets covered high land in and south of South Australia.

The next incursion of the sea into Australia took place in the Cambrian Period about 600 million years ago, and marks the first clearly defined chapter in geological history. The Cambrian Sea was an extensive one, dividing Australia into two islands, covering the centre from the Barkly Tableland in the north to the Mount Lofty Range in the south, much of western Victoria and western Tasmania. Of great scientific interest is the picture, now first afforded, of extensive life in the sea, and considering the earliness of the period, life of complex and advanced organization. Among the fossils found are extinct crustaceans called trilobites, primitive echinoderms, worms, shells, and large masses of reef-building organisms called Archaeocyathinae, which were something between a sponge and a coral. Fossils of this period are particularly abundant on the Barkly Tableland.

After the Cambrian Sea had receded and during the next 200 or 300 million years there were three great incursions of the sea into Australia, each progressively more to the east. The earliest of these, the Ordovician, occupied a great gulf, covering the present site of the Macdonnell Ranges in central Australia and stretching south over western and southern New South Wales and nearly the whole of Victoria and Tasmania. The eastern part of Queensland was also probably under the sea during this period.

Following the Ordovician Period mountain building and erosion were the main events for a long while, then the Silurian Sea invaded eastern Australia in three areas. A long gulf covered western Tasmania and penetrated Victoria north of Melbourne, another gulf entered the land from southern New South Wales and penetrated north-west for some hundreds of miles, and much of eastern Queensland was also under the sea

In the Devonian Period which followed, the sea remained in some of the areas

The land mass which we know as the Australian Continent was not this shape in Ordovician times, but it is known that more of its present area was then covered by sea than in any geological period except the Cambrian.

After Andrews, Bryan and Jones.

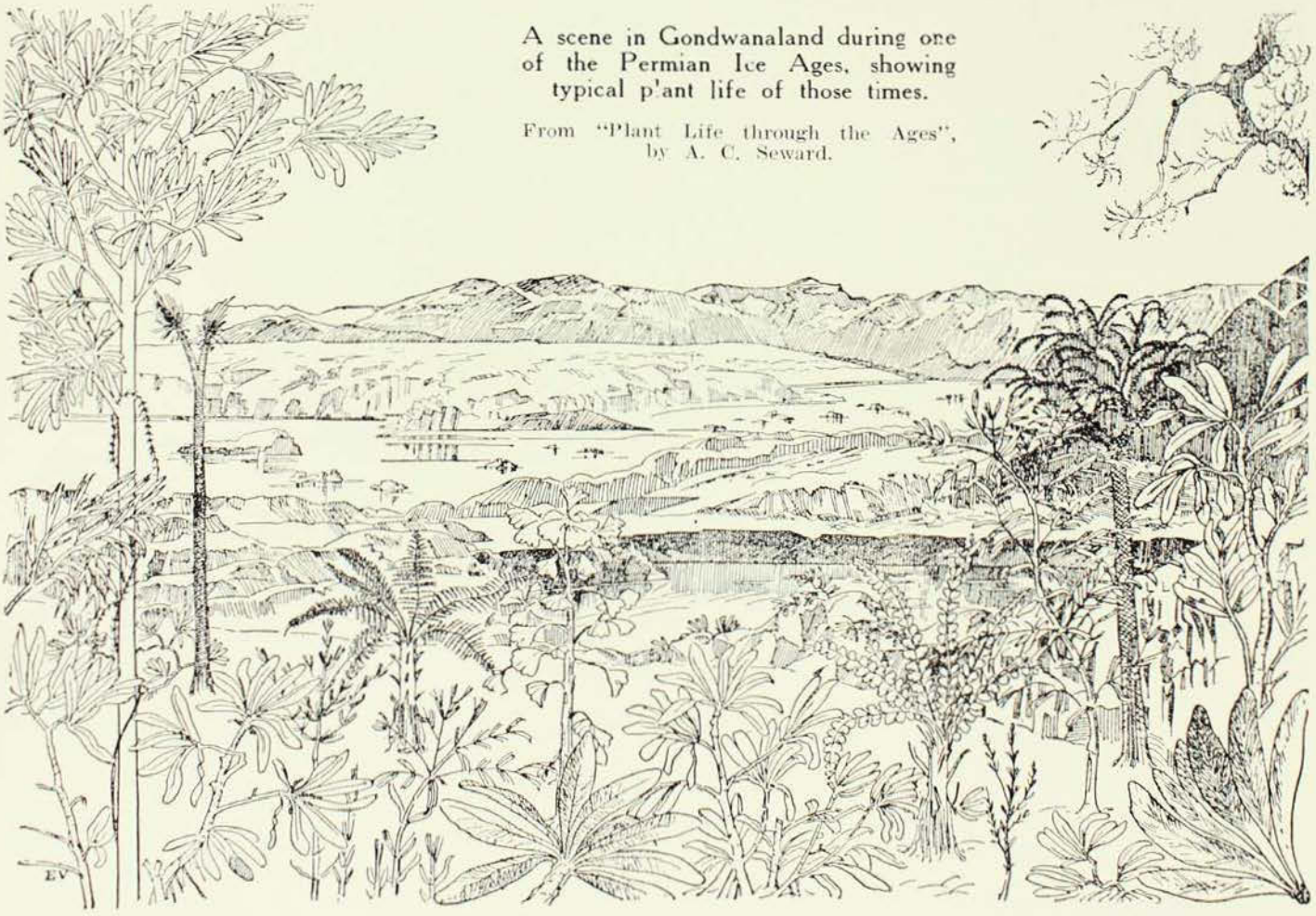
formerly occupied by the Silurian Sea; elsewhere as levels changed it moved its position. The gulf to the north of Melbourne was now dry land, but eastern Victoria and south-eastern New South Wales were still below sea level, as were large parts of eastern Queensland. Towards the end of this period in New South Wales the sea became wider and very shallow; then it silted up and was replaced by large lakes and swamps. In the far north-west extensive gulfs also penetrated the land on either side of the Kimberley Peninsula.

Throughout all this time there had been a steady development of life in the sea. In the Ordovician Sea swarms of graptolites, simple animals of disputed affinities, swam on the surface, and when they died sank to the bottom to be preserved in the mud. In the Silurian and Devonian Seas there were vast coral reefs which now form large beds of limestone. In the Devonian large fish and fish-like creatures appeared, sharks, lung fish and lobe fins, the last thought to be the ancestral types from which land vertebrates first developed. Plant life also first invaded the land in Silurian times, at first as moss-like plants

which have been found in Victorian rocks. These developed slowly into simple, flowerless plants such as ferns and scale trees and, by the Devonian, parts of the land were covered by low thickets and forests.

In the next period, the Carboniferous, there was a small area of the sea in the northern Kimberleys. The rocks composing the Grampian Mountains in Victoria were mostly laid down in lakes, but at one stage the sea came in for a while. In New South Wales a large strait entered the land from just north of Newcastle, ran to the north-west and north, to join the coast again in southern Queensland, leaving the present area of New England as an island. There were many lakes also, but the vast coal swamps which make this the great coal producing period in the northern hemisphere were absent. It was in the next period, the Permian, and even later, that the important coal seams of both eastern and western Australia were formed.

The Permian Sea, some 200 million years ago, also overflowed the land in several areas. In Western Australia most of the Desert Basin and the North-western Basin were under the sea, and these areas are now assuming importance in the search for oil. In eastern Australia a large area in New South Wales to west of the present Blue Mountains a still larger area in southern Queensland, and another in eastern Tasmania alternated between sea and large coal swamps in which important seams of coal were formed. The rocks deposited in the New South Wales area now lie in a huge, depressed basin, and at a depth of approximately 10,000 feet below Sydney. Apart from the wealth of the marine fauna, one of the striking features of this period was the cold climate. It is one of the great glacial epochs in the world's history, the glaciation extending over much of the southern hemisphere, as far north as India, and also in South Africa and South



A scene in Gondwanaland during one of the Permian Ice Ages, showing typical plant life of those times.

From "Plant Life through the Ages", by A. C. Seward.

America. In Victoria, Tasmania and South Australia, great ice sheets flowed over the land from mountains which now lie beneath the sea far to the south—the shadowy, lost and sunken continent of Gondwanaland. Icebergs floated far and wide over the cold seas to deposit, as they melted, their loads of boulders and glacial clay on the sea bottom. Glaciers also existed in the Kimberleys and on high land elsewhere in Australia. It was in the Permian also that large forests first appeared in Australia, including pines, and also insects and land vertebrates in the form of the curious amphibian, Labyrinthodont.

In the next 150 million years, covering three great geological periods and the whole of the Mesozoic Era, Australia was largely a land of vast central lakes, occupying what is now the Great Artesian Basin. Apart from one or two small incursions in the far north-west earlier in the era, it was not until near its end, in the Cretaceous Period, that the sea again invaded the continent. This time it came in from the north, covering central and western Queensland, north-western New South Wales, parts of South Australia, and reaching almost to the Great Australian Bight, thus nearly severing Australia into two islands. It was a cold sea, without coral reefs, but with a rich fauna of marine life, including the giant fish lizards or ichthyosaurs. Shells and bones can be found at White Cliffs and other opal fields, sometimes converted into solid opal. This was the age of giant reptiles, whose enormous size and bizarre forms have been made familiar by many writers.

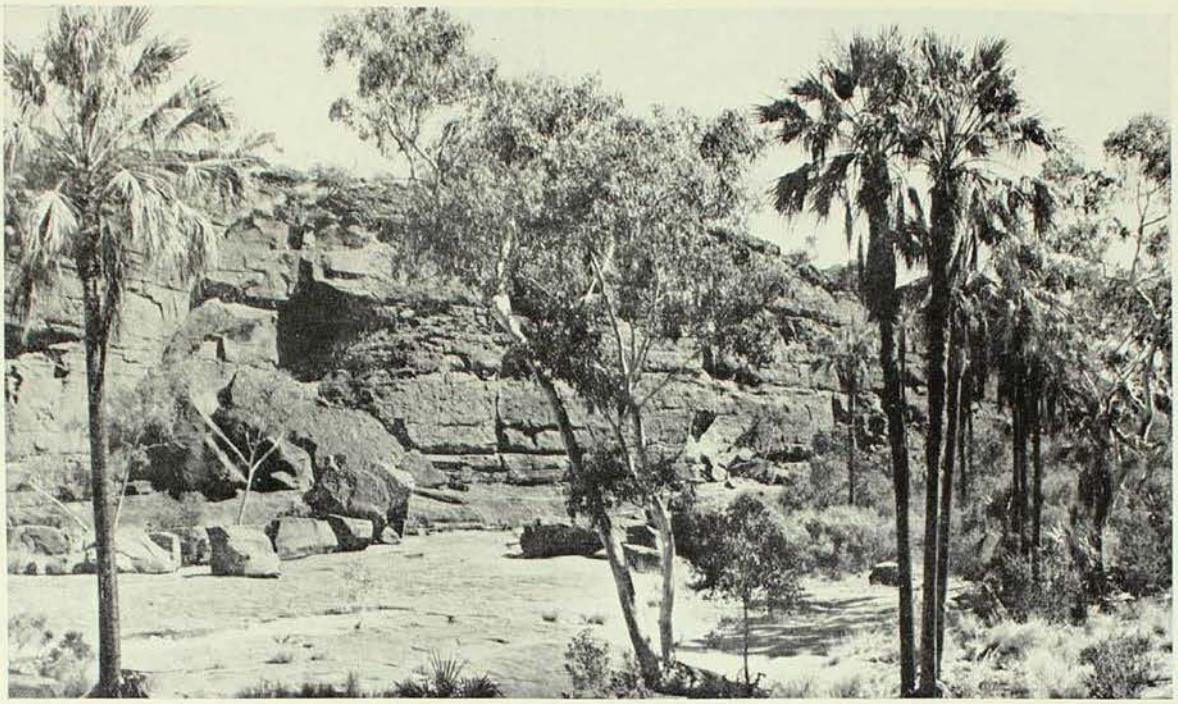
It was towards the close of the Cretaceous, some 50 or 60 million years ago, that submergence of lands to the north of Australia closed land bridges from the rest of the world, and led to the development of our unique land flora and fauna. The first flowering plants had come to Australia during this period, as had the early mammals, probably primitive marsupials akin to opossums. Henceforward they were to develop in isolation, adapting themselves to changing conditions, and evolving into the many families and genera peculiar to this country.

We come now to the last of our seas, the Miocene Sea, which invaded Australia from the south about 25 million years ago. At its greatest the Murray Gulf submerged part of northern Tasmania, and practically the whole of western Victoria, it lay over what are now the Mount Lofty Ranges, and extended into New South Wales some distance above the junction of the present Murray and Darling Rivers. Farther to the west the Nullabor Plain was under the sea, and a few narrow areas on the west coast of Western Australia. The rocks deposited are particularly rich in marine fossils, including many extinct sharks and whales.

Since then there have been many geographical and climatic changes in Australia, but these pertain more to the land than to the sea, and are outside the scope of this article. We therefore can do no more than mention the Pliocene Uplift several million years ago which elevated the eastern plateaux, the Pleistocene Ice Age from about one million to 10,000 years ago, followed by the drying of the climate and the extinction of great herds of marsupials which once roamed the central plains. Nor is there space to tell of the earlier and later volcanic eruptions, nor of the building of mountains, nor of the one time great lakes, nor a hundred other things which are all part of the geological story of Australia.

. . . *Films for School Children* . . .

Half-hour film sessions for school children and their parents will be held in the Lecture Hall of the Australian Museum at 2.30 p.m. daily from January 7 to January 25, 1957 (Saturdays and Sundays excepted). Admission is free. For further details please telephone BM 6954.



Scene in Palm Valley, Macdonnell Ranges, Central Australia.

Photo.—Author.

Australian Flowering Plants

By WINIFRED M. CURTIS

Reader in Botany, University of Tasmania

IN the year 1860 Sir Joseph Dalton Hooker wrote: "The flora of Australia has been justly regarded as the most remarkable that is known, owing to the number of peculiar forms of vegetation which this continent presents." This famous botanist and author of the first comprehensive account of Australian plants ("Flora Tasmaniae") had sailed as a member of the expedition under the command of Sir James Clark Ross which, during the years 1839-1843, explored antarctic lands. Botanists today, like the pioneers of Australian botany a hundred years ago, find it interesting to see how many of our plants are specialised (or "peculiar") and suited to special environments, and also to consider the relationship between these plants and those of other countries.

Plants grow together in characteristic assemblages, for example we readily distinguish eucalypt forest, heath, grasslands, desert grasslands and steppe, tropical rain forest, mangrove forest, temperate rain forest and alpine communities. In the subhumid and semi-arid climates a number of plants contribute to the scenes that are essentially Australian. More than 500 species of *Eucalyptus* occur, ranging in form from stunted shrubs and mallees to trees which are among the tallest in the world; they are native only in this continent with a few species in the neighbouring islands to the north. Many such as the mountain ash, *E. regnans*, of cool mountain valleys, are trees with shaft-like trunks from which the bark peels in long ribbons —a feature rare in trees of other lands. All eucalypts are characterized by their flower, in which the sepals and petals form an operculum or hard covering lid which is pushed off when the numerous and often brightly coloured stamens mature. The family *Myrtaceae* which includes the eucalypts is represented in Australia by 45 genera. All have leaves which are gland-dotted, often small, and somewhat thick and hard; many plants such as bottlebrushes and tea-trees are abundant and

Mountain Ash (*Eucalyptus regnans*), w th understorey of musk (*Olearia argophylla*) and tree-ferns; Weldborough, Tasmania.

Photo.—Author.

very familiar. The largest of the families of flowering plants in Australia is the *Leguminosae*. This includes the wattles and the pea-flowers, the latter responsible for much of the colour of the bush in spring and early summer. Wattles are widespread and often tolerate drier conditions than eucalypts. Nearly 600 species are known in Australia many of which are characterized by an interesting modification of the leaf. True and much-divided leaves are formed only in the seedling stage, or sometimes in the adult plant following injury, usually the leaf-stalks become expanded and flattened, forming leaf-like structures termed phyllodes. Phyllodes are often hard and rigid, they are attached to the axis vertically and therefore are held edge-on to the incident sunlight. Such structures are well adapted to withstand the effects of intense light and dessicating winds.

Growing often in drier parts of eucalypt forests and woodlands are she-oaks, (*Casuarina* spp.). These small trees or shrubs are predominantly Australian but a few species, often strand plants, occur in tropical Asia and the Pacific islands; the plants have an interesting and specialized structure. A number of branches arise in a whorl, *i.e.*, at the same level on the axis. Each young branch is slender, green and longitudinally furrowed; it is encircled at intervals by leaves which are reduced to brown, tooth-like scales. The plant looks like a giant horsetail, *Equisetum*; one she-oak is named *Casuarina equisetifolia*. The resemblance is superficial for horsetails are not flowering plants but are pteridophytes allied to ferns and clubmosses. Their living representatives (not found in Australia) are small plants rarely more than 3 feet high, although fossil forms such as *Calamites* of Palaeozoic coal measures were large trees. Because of the similarity in form between *Casuarina* and plants belonging to the relatively primitive group of pteridophytes, the former is often (erroneously) said to represent an ancient type. However, flowering plants are of relatively recent origin in geological time and the peculiar morphology of *Casuarina* is an interesting example of the xeromorphism* that characterizes many Australian plants. Another interesting plant

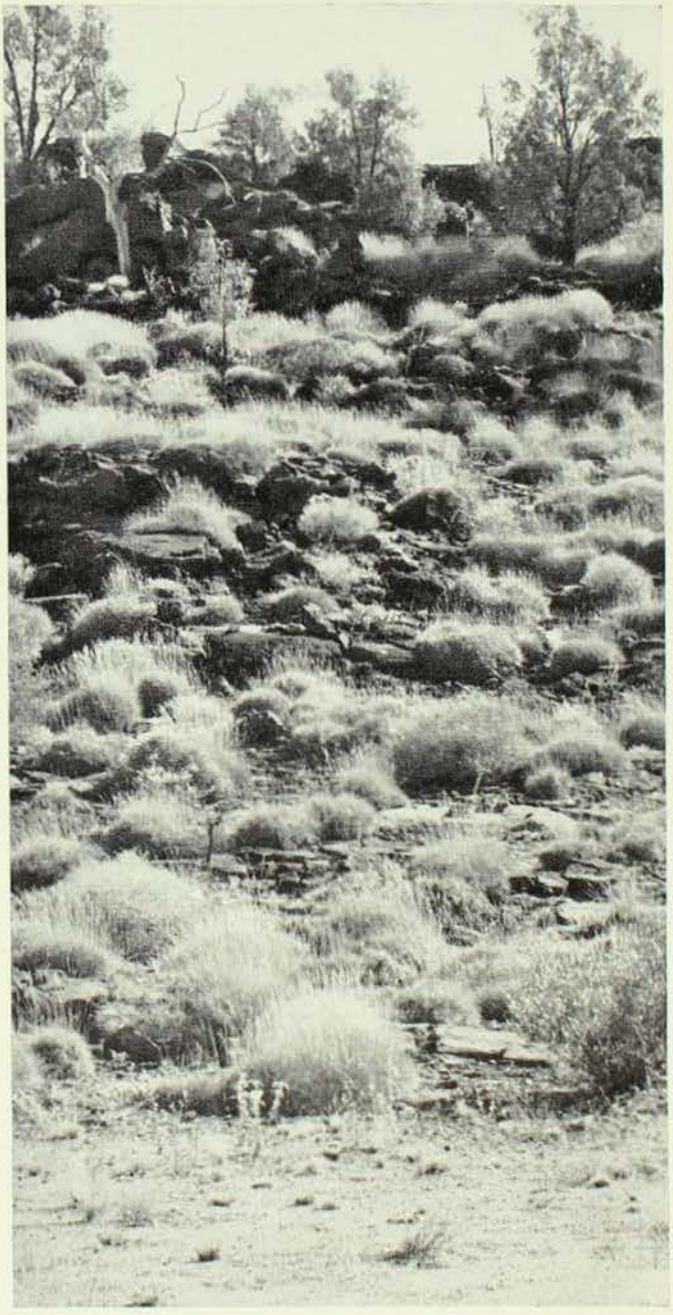
* A xeromorphic plant is one having the structural peculiarities of a plant which is able to survive in a very dry habitat. Such a plant may be succulent, *e.g.*, cactus, or semi-succulent, *e.g.*, saltbush, or sclerophytic, *i.e.*, having leaves that are hard because provided with much strengthening tissue, with a good vascular system, and with thick cuticle or well-developed covering of hairs; such leaves are often small or rolled or replaced by phyllodes. A xeromorphic plant is not necessarily able to survive drought; *i.e.*, it is not necessarily xerophytic. All eucalypts are xeromorphic, but while some species are drought resistent (xerophytic) others can grow only in sheltered gullies.

with equally reduced leaves is a partial parasite on the roots of eucalypts and other trees. This is the native cherry, *Exocarpos cupressiformis*, a small tree with an unusual fruit. The fruit is a small hard nut borne at the end of a fleshy and conspicuous fruit-stalk. The peculiar appearance of a "fruit" with a stony part outside the flesh is responsible for the generic name which is derived from two Greek words *exo*, outside, and *karpos*, fruit.

The family *Proteaceae* provides many of the characteristically Australian plants. The flowers are sometimes small but are then crowded in conspicuous inflorescences; numerous clusters in *Hakea*, dense cones in *Banksia*, terminal groups surrounded by large bracts in the waratah, *Telopea*. The leaves are strongly xeromorphic, they are thick, hard, and sometimes divided into narrow pungent segments. The *Proteaceae* is represented in all the lands of the southern hemisphere but reaches its greatest development in Australia and particularly in the south-west of the continent; there is another major centre of development in South Africa. Although the Australian and South African genera are endemic in their respective areas, it is evident that there is a strong affinity between the xeromorphic vegetation of the Cape Peninsula and of southern Australia.

Characteristic plants of the arid communities in Australia include the saltbushes, *Atriplex* spp., which have an unusual property, that of absorbing water through their leaves when the surrounding atmosphere is nearly saturated. This condition is liable to occur at night when the temperature may fall quickly and very considerably and a valuable source of water is thus available. On the extensive desert sandhills of the interior the most widespread plant is a porcupine grass or spinifex, *Triodia basedowii*, which grows in isolated tussocks. This and other xerophytic species of *Triodia* are highly specialised, they are very woody and have leaves that are exceptionally hard and pungent-pointed.

In the parts of the continent where rainfall is comparatively high, such as 60 inches or more well distributed throughout the year, the plants and plant communities contrast strongly with those already described. In parts of Queensland and northern New South Wales good soil supports a luxuriant growth of tropical rain forest. The trees have distinctive and characteristic growth forms, they frequently grow in dense stands to a height of 90 to 120 ft. the tops forming an almost continuous canopy, the trunks straight but in many species flaring out to form plank-buttresses at the base. Many different



Spinifex (*Triodia* sp.) at the entrance to Palm Valley, Macdonnell Ranges.

Photo.—Author.

Temperate rain forest, Tasmania.

Photo.—J. B. Thwaites.

families are represented and in this community few of the genera are restricted to an Australian distribution; most occur also in the similar forests of New Guinea, Malaya and India. In these forests light is the chief factor controlling growth and there are many epiphytes and climbers. The Moreton Bay fig, *Ficus watkinsiana*, has a growth form which is particularly successful. Seeds from the edible fruits become lodged on the branches of other trees and germinate there. A seedling forms a woody tuber, then a long root which reaches down to the ground. Soon additional roots follow and join together forming a network which surrounds and finally strangles the host-trunk; the fig branches then spread at the top of a stout lattice of overground roots.

On coastal mud flats and tidal estuaries in the warmer and wetter parts of the continent mangrove forests may be found. Such forests are widespread in tropical and subtropical regions throughout the world; they are another example of a community which contains a number of unrelated plants having a peculiar life form. The conditions of the habitat are exacting, they include a soft substratum which is regularly covered and exposed by the rise and fall of the tides, is subject to considerable fluctuations in salinity, and which is always waterlogged and therefore without adequate air supply for the roots of plants. Several characteristic features of mangroves help their establishment and growth in such habitats. Often the trees are viviparous, *i.e.*, the seed germinates before it is shed from the fruit and the seedling which is set free is equipped with an efficient anchoring root. Aerating mechanisms are interesting. They depend on special developments of the roots. In *Avicennia* shallow horizontal roots send up numerous erect branches or pneumatophores which project several inches above the surface.

The temperate rain forests which develop in suitable areas of high rainfall in Tasmania and Victoria and also in zones of heavy mist on the mountains of New South Wales and Queensland, show affinities different from those of the other plant communities of Australia. The distinctive

genus *Nothofagus*, the southern beech (often in Tasmania called "myrtle"), is subantarctic in distribution and characterizes the corresponding forests of New Zealand, Chile and Tierra del Fuego. In Tasmania some of the forests are extraordinarily dense and progress through them can be made only by cutting a track and at the rate of scarcely a mile a day. Here there is a very interesting association of plants. *Nothofagus* is always associated with a sassafras, *Atherosperma moschatum*, representative of a family (Monimiaceae) which is mainly tropical and subtropical in distribution. In localized areas of waterlogged soil a sedge or "cutting grass", *Gahnia psittacorum*, forms tussocks 6 to 10 ft. high. This species grows also in Malaya, but in Tasmania where it reaches the southerly limit of its distribution the sedge is restricted to very wet places. The majority of the flowering plants of the forest and of the mountain slopes above the trees are subantarctic in affinity. Forest, subalpine scrub, moor and bog are remarkably similar in appearance and in floristic composition in the three major land masses of subantarctic latitudes.

A picture of the distribution of the diverse plant communities throughout Australia may be built up on the basis of maps showing rainfall and summer temperatures. The picture (inevitably oversimplified) is of an arid centre, the desert sand-ridges characterized by spinifex and by a few xerophytic shrubs, surrounded by progressively wetter zones supporting various sclerophyllous communities, in the south mainly scrub and in the north grasslands and savannah woodland, followed in turn by eucalypt forests. Rain forests of both tropical and temperate types occur in suitable areas in eastern Australia.

The pattern is greatly influenced by local conditions of which the most important are due to soil, particularly in respect of properties of water-retention. Thus adjacent areas differing in soil but in the same climatic zone may in Queensland carry tropical rain forest or eucalypt forest or heath or, in Tasmania, temperate rain forest or sedge-moor. A spectacular assemblage of plant communities is found in the Macdonnell Ranges of arid central Australia. Here, permanent water in Palm Valley maintains a community characterized by the palm *Livistona mariae*, while the sides of the valley carry mulga (a xerophytic wattle) and the adjoining sand-plains support little besides spinifex. The pattern of distribution of the plant communities therefore becomes an intricate mosaic; the interpretation must be through studies, not only of the present climate but of past climates and the geological history of the continent. Such studies have been summarized by Crocker and Wood,[1] and by Herbert[2].

Fossil plants have been identified which show that the kinds of plants growing in Australia today also grew throughout the continent in the early Tertiary era, 70 to 45 million years ago. After the retreat of the Cretaceous seas from the centre of Australia there followed a long period of climatic stability with abundant rainfall, and during the Oligocene period the flora throughout the continent was surprisingly uniform. Genera such as *Eucalyptus*, *Banksia* and *Hakea*, were widespread and grew together with *Nothofagus*, a representative of the subantarctic element, and with *Flindersia* and other tropical rain forest types. During the Miocene period the advance of sea over land in the region of the Great Australian Bight isolated the floras of the eastern and western parts of the continent, an isolation that has continued because of subsequent barriers of soil and climate. There is evidence also that during this period the climate became warmer and that there was a southward migration of Indo-Malayan types. Today in Tasmania such flowering plants and ferns are found associated with *Nothofagus*.

The earth movements of the Miocene period initiated the uplift of mountain ranges in eastern Australia and created

[1] Crocker, R. L. and Wood, J. G. (1947). Some Historical Influences on the Development of the South Australian Vegetation Communities and their bearing on Concepts and Classification in Ecology. *Trans. R. Soc. S.A.* 71 (1), 91.

[2] Herbert, D. A. (1950). Present Day Distribution and the Geological Past. *Vic. Nat.* 66 (12), 227.

new habitats for plants. *Nothofagus* and other subantarctic types persisted in areas suited to them not only in the most southerly parts of the continent but also as far north as Queensland and in New Guinea. At the same time the distinction between the eastern and western parts of the continent was intensified. While in eastern Australia there developed a diversity of habitats suitable for the growth of rain forests and of alpine plants as well as for the characteristically Australian xeromorphs, in western Australia conditions favoured only the latter types.

The Quaternary era brought great fluctuations in climate with alternating glacial and interglacial phases, at times conditions were such that *Nothofagus* and other characteristic plants of the temperate rain forests could greatly extend their range. But destruction of the native vegetation over much of the continent took place in the arid period which followed in a Recent age, perhaps 6,000 to 4,000 years ago. Remnants of the pre-arid flora have survived in the plant refuges which occur in places among the hills and mountains. This must be the explanation of the existing mesophytic communities of palms in the Macdonnell Ranges.

Today, particularly in eastern Australia where a number of different plant habitats may be in juxtaposition, the pattern of plant communities is complex. Boundaries between the vegetation types—Australian, Indo-Malayan, and subantarctic—are still changing as habitats change. Always the survival of a particular kind of plant depends on the ability of its seeds or germules to reach and to colonize suitable ground; the method of spread is of great historical significance. Although the present types of plants may be recognized in Australia in the early Tertiary the nature of the northerly link with Malaysia and the southerly link with subantarctic lands is still debatable. If the related plant species now characteristic of the separate land masses of the southern hemisphere have evolved from common ancestral stocks there are two ways of spread to be considered: by long distance dispersal of seed across oceans such as exist today, or by migration along land connections which previously existed between the continents that are now separated. A land route—either a series of land bridges or island links, or a great southern land mass, Gondwanaland, from which the continents separated and gradually drifted to their present positions—does not solve all the botanical problems. Plants spread only through regions of suitable soil and climate. Study of the methods of spread and establishment of Australian plants today may help towards solving the mystery of the method of colonization of the continent in geological time.

Book Review

NATURECRAFT IN AUSTRALIA: An Introductory Handbook to the Flora and Fauna and to the Australian Environment, for the use of the Bushwalker, Student, Teacher, Field Naturalist and Conservationist. Arranged and Edited by Thistle Y. Harris, p.p. XVI+264, Angus & Robertson, Sydney, 1956. (Price, 25s.)

This well illustrated book, which is published under the auspices of the Wild Life Preservation Society of Australia, covers a wide field. At the beginning some simple facts of Physical Geology are given and these are followed by accounts of Australian animals, both vertebrates and invertebrates, and plants, including trees. At the end there is a section on bush lore and another on conservation. For those who have specialized knowledge in any of the several fields covered there is much in this book which is not entirely satisfactory, but it was not written for specialists but for children and others as their introduction to natural history in Australia. Judged by this standard it is quite certain that *Naturecraft in Australia* fills a real need and can be recommended as a primer for young naturalists.

Miss Harris (Mrs. D. G. Stead) is an enthusiast with energy and determination and all who have an interest in our heritage of animals and plants are in her debt for this work and for her other activities undertaken in her capacity as Honorary Secretary of the Wild Life Preservation Society of Australia.

J. W. E.

The Peopling of South-Eastern Australia

By NORMAN B. TINDALE

Curator of Anthropology, South Australian Museum.

FIRST people to enter Australia were Asians, as was to be expected since Asia is the nearest land where modern man is truly native. They were latecomers because of man's lack of ability to travel over the sea until quite late geological time. The discovery of Australia may be said to be one of the chance consequences of the invention or discovery of the art of navigation and of the devising of the first simple rafts and bark canoes.

A folk of Negrito stock, tiny people not over 5 feet in height, arrived on the Australian mainland some time rather late in the Great Ice Age, perhaps when the succession of ice cold periods was already nearing the maximum of the Last Cold Phase, more than 15,000 years ago. Their journey was one of many small voyagings, probably never out of sight of land, from island to island across the tropical waters of Indonesia. These journeys were probably not undertaken in any continuous manner but man arrived here as the end result of a long series of random voyages whose culmination may have taken centuries.

They were not long left in undisputed possession of their new land, for even before the end of the Ice Age a second wave of people, the taller Southern Australoids, was hard in their footsteps and also appeared on the scene, having followed the negrito along much the same lines of island stepping-stones from Asia. Both these people are still represented in Asia by folk whom they left behind.

During the Ice Age so much water had been removed from the sea and stacked up as ice on the lands nearest the North and South Poles that the sea shores were in very different places from where they are now. For this reason the land the newcomers found was much larger than it is to-day. Australia, New Guinea, Tasmania and the larger islands of Australia, such as Melville and Bathurst Islands and Kangaroo Island, were all one great land joined together and the sea shore nearly everywhere stood far out to sea beyond where it is now. After the Ice Age was over 250 feet of water released by the melting of the ice covered the old shorelines. Thus very few shoreline camps of the earliest Australians can be found to-day, since only on cliffs fronting deep water is the coastline substantially in the same vicinity as in those days.

When we go looking for the ancestors of the Australians we find that at Wadjak in Java there are remains of a people who were among the earliest if not the first type of modern man in Indonesia. The best preserved remains are those of a Wadjak woman. A general idea of her probable appearance can be obtained by drawing standard amounts of fleshy parts over the outline of her skull and tinting her a neutral shade of brown, as has been done in a reconstruction portrait by Mr. H. T. Condon of the South Australian Museum (Fig. 1).

One other find of early man has been made near Australia. It is a part frontal bone of an Australoid-like skull, in interglacial seashore deposits of the Ice Age, now lying far above sea level at Aitape in northern New Guinea. This bone was found by a geologist, Dr. Paul S. Hossfeld.

On the present Australian mainland the earliest dated find so far established is that of a youth at Tartanga on the Murray River (Fig. 2). This lad died, at the age of about twelve, in a year very close to 6020 B.P. (*i.e.*, Before the Present). This date was fixed by a test of the Carbon 14 in the food shells left over after he and his fellow men had eaten at Tartanga.

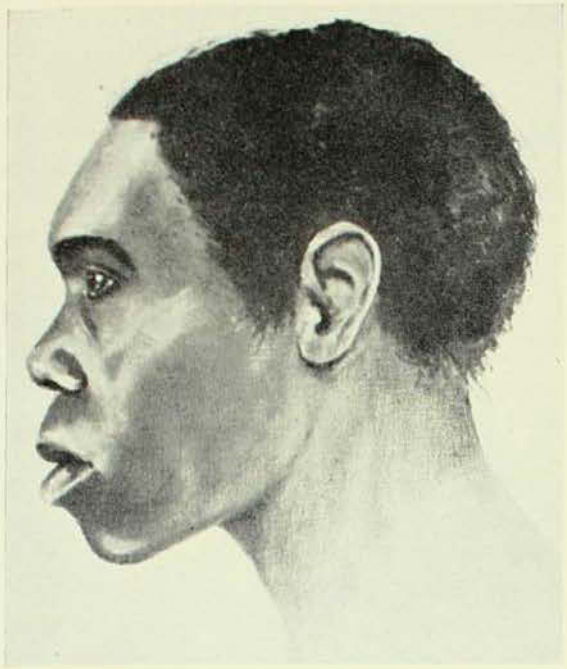


Fig. 1. (*Above*): Restored portrait of a Wadjak woman, Java. Fig. 2. (*Top Right*): Tartangan youth of 6,020 years ago; a restored portrait.

Photos.—South Australian Museum.

Fig. 3. (*Left*): Cohuna man; restored portrait of an early Murrayian man (S.A. Museum). Fig. 4. (*Above*): Barrinean negrito man of Atherton Tableland, Queensland.

Photo.—N. B. Tindale.

Other C^{14} tests suggest that his people had already lived in the area for nearly 3,000 years. The Tartangan boy was of short stature and probably of negrito stock.

At about the same general time, or a little later, there lived at Cohuna, on the Upper Murray River in Victoria, an Australoid type of man whose people fed on shell fish of the same kind as Tartangan men. The generally robust appearance of Cohuna man may have been something like the restored portrait shown in Fig. 3. Men of his type are called Murrayians, and they replaced the Tartangans over much of Australia by about the Middle of Recent Time.

At Keilor, in Victoria, a similar Southern Australoid skull has been found; its date is not yet established but a single stone implement found near the skull suggests he possibly was born a thousand or more years later during the time when people of the culture called Pirrian were living. In later paragraphs we will have something more to say of the Pirrian folk.

There was a third migration of people into Australia, whom we know only from the living type, the Carpentarians of the North Australian coasts. The Carpentarians are the aboriginals of the popular Jolliffe cartoons, tall, slender, and with only scant body hair. The Carpentarians are relatively newcomers to this country but beside them we Western Europeans are veritable "new chums" for they must have been here for many centuries.

When men of the Western World first came here the negrito type of man was present in Tasmania and at one time it was uncertain how he came to be there. More recently the writer of this article, with Dr. J. B. Birdsell, was a participator in the re-discovery of negrito-like survivors of the earliest aborigines in the rain forested areas of the Atherton Plateau of Queensland. Some ten tribes of them survive in Queensland, no more than about 600 persons in all, of what was once an Australia-wide population. Normally the Barrinean negrito people, as they are now termed, cremated their dead, or rather burned their bones, for until recent years they were inveterate cannibals. During the Native Police atrocities of the late years of last century a small series of skulls was gathered by Dr. Roth, and came to the Australian Museum which is thus the the possessor of almost the only dozen known skulls of these negritos. One or more of them are peppered with shot, showing how the negritos died.

The people of the second invasion of Australia, Southern Australoids, were named the Murrayians by Dr. J. B. Birdsell because they are the typical people of the Murray River Basin. They are heavily built, light brown skinned people with much hair on their bodies. Today they are rapidly dying out, having been unable to withstand contact with the diseases of our own race, coughs, colds, measles and the like. Soon there will be Australian blackfellows surviving only in Northern Australia, where people of the Carpentarian type predominate.

Our ability to give an outline of the past history of the several peoples of Australia comes from the piecing together of the evidence provided by geologists and archaeologists, and also from the discoveries of those wizards of science, the physicists. Most of all we are indebted to the discovery by Dr. Willard F. Libby and his colleagues, that the carbon of living tissue has a fixed proportion of Carbon 14 in its make-up. As soon as death occurs this C^{14} begins a slow change to ordinary carbon. Thus if we find old organic carbon, whether it be charcoal, burnt bone or shell fish, it will have less C^{14} in it than living tissue and the older it is the less it will have. After 5568 years one-half of the C^{14} is lost. So by delving in rock shelters and on camp sites and establishing the succession of styles of workmanship of man's stone tools, and by obtaining samples of his food remains and of his fire hearths, something has been learned of the habits of the several peoples who have lived in Australia, and of the dates of the various events. In time we will learn a great deal more about these folk.

The stone implements of the earliest Australians seem to have been made from pebbles and blocks of stone, and in general they were large and coarsely made. The earliest industry has been termed the Kartan Culture, because it was first noticed on Karta, which is the Ramindjeri aboriginal name for Kangaroo Island off the coast of South Australia. Kartan Culture relics have since been identified over much of Australia, in Tasmania, in the Bass Strait Islands, and on Bathurst Island, in the Northern Territory. The best known implement is the "sumatra" stone, so named because it was first found in Sumatra. In Asia the Hoabinhien Culture has implements similar to the Kartan Culture, which is not really surprising since Kartan man must have come from Asia. An implement like a sumatra of the Kartan Culture is shown in Fig. 7. It was found

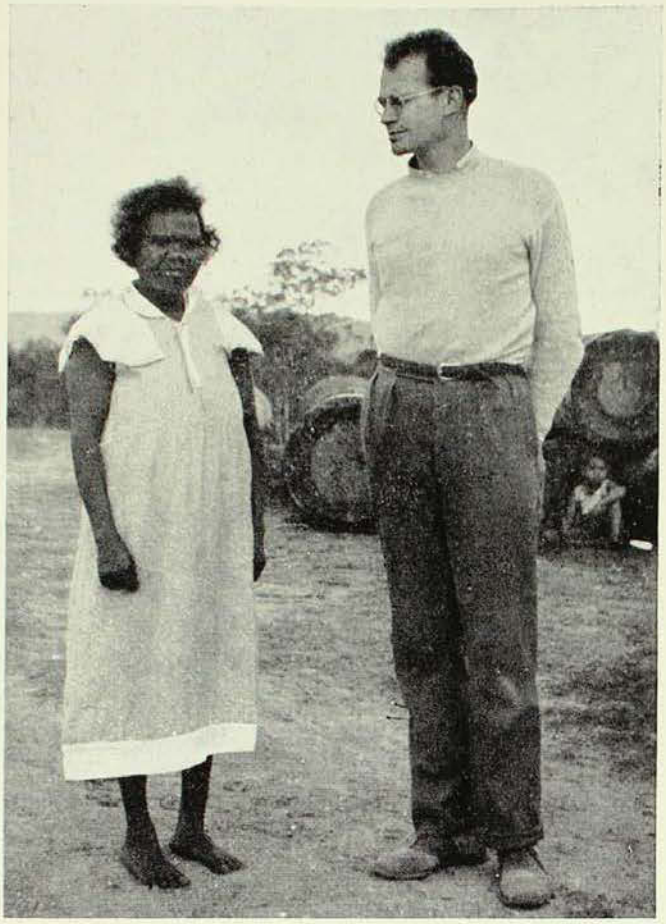


Fig. 5. Dr. J. B. Birdsell and a Barrinean negrito woman.

Photo.—N. B. Tindale.

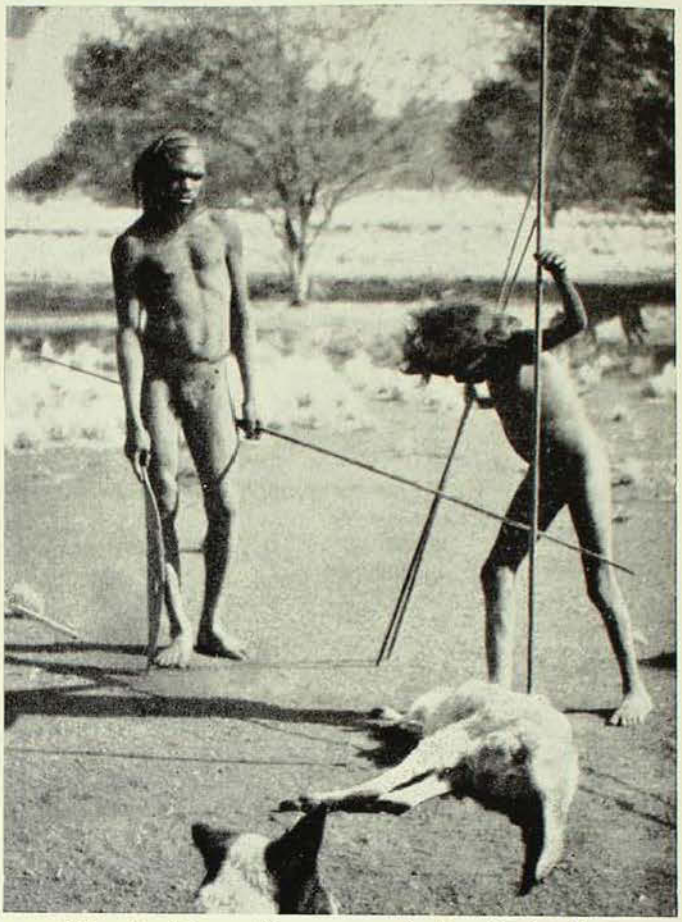


Fig. 6. Murundian man of the Pitjandjara tribe who has just speared a kangaroo, south of the Mann Ranges in the Western Desert.

Photo.—N. B. Tindale.

by a palaeontologist, Dr. Brian Daily, on Bathurst Island and has been "rolled" and worn by water action. The photographs show it from two directions, the scale beside it is in centimetres.

From discoveries at Hallett Cove, south of Adelaide, we know that Kartan men were in Australia before the end of the Ice Age, and they must have settled in Tasmania and on the areas that are now Kangaroo Island and Bathurst Island before the rise of sea level which marked the end of the Ice Age. On Kangaroo Island the Kartan people who were shut away by this rise of sea level lingered on until the middle of Recent Time, just on 5,000 years ago, when they disappeared, and Kangaroo Island then remained uninhabited until modern times, save perhaps for a few possible chance landings by later aborigines, who did not stay. Before Tasmania was cut off by the same rise of sea level a second wave of people with a different style of stone implement culture, the Tartangan folk, had already arrived in Southern Australia and had followed the Kartan people into Tasmania.

The Tartangan people seem to have either amalgamated with or killed out the Kartan people who were on Tasmania and continued to enjoy a form of the Tartangan Culture there until just on 90 years ago, when men of our race were responsible for their extinction when we took over Tasmania for white settlement.

The earliest positive Carbon 14 date yet established for a specific cultural horizon is that for a Tartangan Culture site at Cape Martin, near Beachport in South Australia, where just on 8,700 years ago (6750 B.C.) these people lived. This was only some 1,300 years after the Ice Age had ended and the oceans of the world had risen to about their present level, cutting off the island peoples of Tasmania and

Kangaroo Island and so providing us with samples of the culture of the peoples of that time.

On the mainland of Australia the Tartangan people used large and very strikingly fashioned disc-like flake knives, much like the Tasmanian ones. They persisted in south-eastern Australia until near the middle of Recent Time (about 5,000 years ago). At Lake Menindee, in western New South Wales, they were contemporary with some of the large mammals and giant birds left over from the Ice Age. One of their camps at this lake is dated to 6570 B.P. but they did not long endure after they had seemingly exterminated the giant creatures. Their camp remains at Tartanga dated to 6020 B.P., show only modern mammals.

In the Mid-Recent, sea level rose temporarily all over the world to about 10 feet above its present height, and remained high for many generations. The climate of Southern Australia at that time probably was a little warmer and moister than it is today. When seas reverted to about their present level a new people, the Pirrians, with a new culture, were to be found in South-eastern Australia. Probably they were the first true Southern Australians to arrive. They had been working their way down from the north for many generations. At Devon Downs, on the Murray River, Pirrian people were living in 4250 B.P. and they must have been present earlier than this for when Mount Gambier spread a sheet of ash several miles wide across the country in 4710 B.P. the first people to leave their implements on the top of the ash seem to have been Pirrians. These folk were noted for their beautiful stone spear points, called *pirri*, which today survive only among a few desert folk of the north-western portion of our Western Desert.

Between the mid-point of Pirrian times and the present we have few useful fixed dates, but perhaps 3,500 years ago in the Murray Valley people using tiny stone implements of specialized types called microliths, appeared. Their culture has been called the Mudukian, and its remains are now known from Perth to Sydney and north to beyond the Tropic of Capricorn. Similar tiny implements are also found in many parts of Asia, Africa and Europe where they first appeared about 10,000 years ago.

In Western Australia and perhaps in a few places in Eastern Australia the Mudukian people lived until modern times. However their old culture came to be modified by new ideas such as that of making polished stone axes and polishing

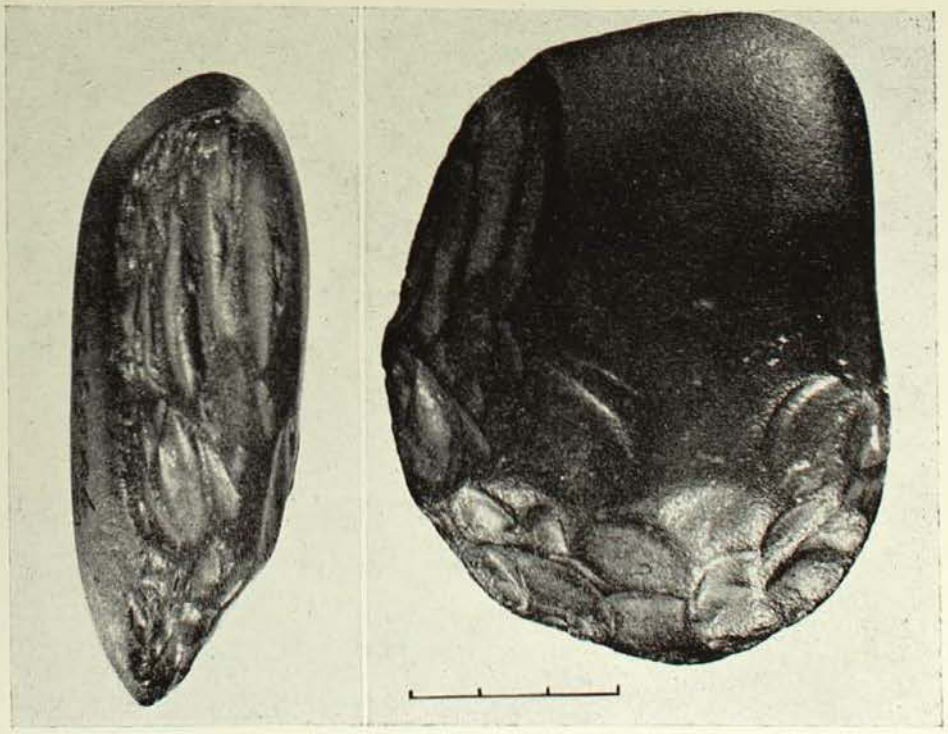


Fig. 7. "Rolled" sumatralith implement of the Kartan Culture, Bathurst Island. (Scale in centimetres).

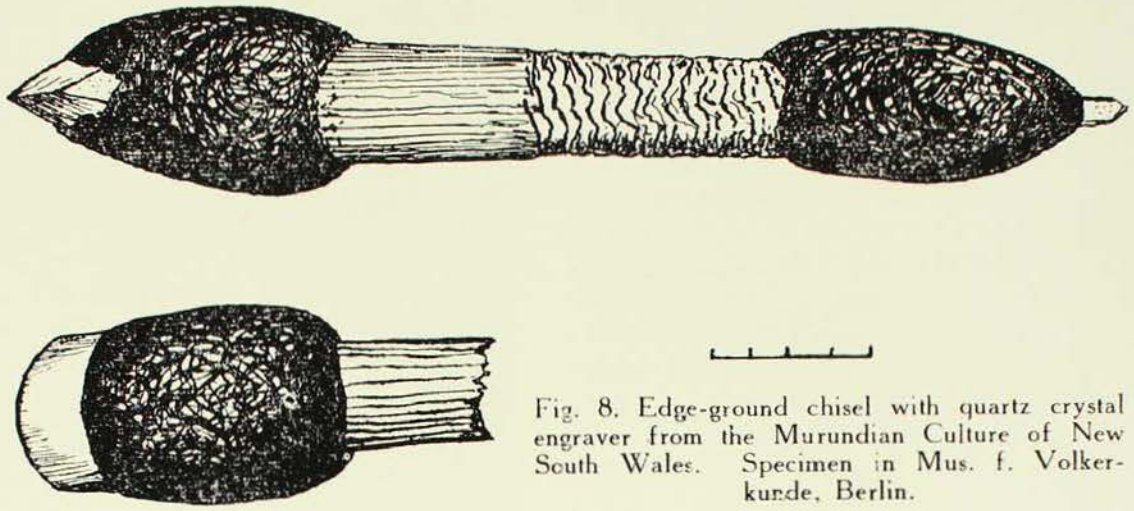


Fig. 8. Edge-ground chisel with quartz crystal engraver from the Murundian Culture of New South Wales. Specimen in Mus. f. Volkerkunde, Berlin.

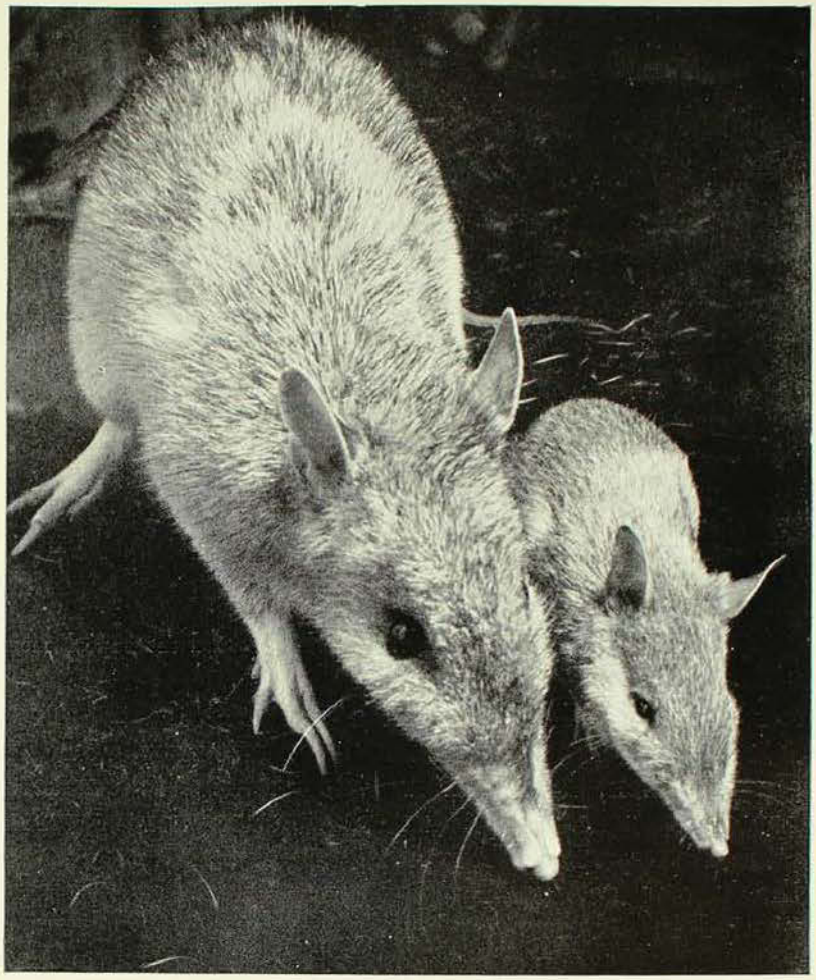
edges on stoen chisels. Fig. 8 is a drawing of a beautifully made polished stone chisel with a quartz crystal at the other end, hafted in gum, which probably came from New South Wales no more than 150 years ago. Its haft is a piece of the handle of a club. This fine specimen, which is in the Museum fur Volkerkunde in Berlin, is one of the few hafted stone relics of its kind still in existence. It is one of the most advanced types of implements in Australia, and a high achievement of the Murundian Culture.

Some 1,000 to 2,000 years ago when the climate of Southern Australia began to deteriorate and become much like the Mediterranean dry climate which the area enjoys today, there came out of the Western Desert and down from the drying interior of Queensland and Central Australia a series of tribes with a new culture, the Murundian. These people were active nomads, living and sleeping naked in the open and possessing few non-portable goods other than wooden water dishes, *leilira* blade stone knives, adze stones on their spearthrowers and an occasional edge-ground stone axe, and polished stone chisel.

In some places tribes, using this Murundian culture, pressed right to the eastern and southern coasts of Australia, as around Adelaide, along the lower Murray and in western Victoria and in the vicinity of the Nepean River, New South Wales, where, as demonstrated by Mr. F. D. McCarthy of the Australian Museum, they deposited several feet of camp debris in a rock shelter at Lapstone Creek. The pressing southward of new peoples continued right up to the time of European settlement and Early day aborigines of the coastal areas of southern New South Wales are known to have evinced great fear of such invaders from over the Great Dividing Range.

Most of the information on which this article is based has been published in the very extensive scientific literature on the subject; a few newly discovered details are appearing in two papers by the present author which are in press, one in the *Records of the South Australian Museum* and the other in the *Transactions of the Royal Society of South Australia.*

Instalments of *EXPLORING BETWEEN TIDEMARKS* and *NATURE QUIZ* will be resumed in the March, 1957, issue.



Young bandicoot (*Perameles nasuta*) about 9 weeks old with its mother. One of a litter of three; the first bandicoots reared to maturity in captivity. Photographed 16th September, 1954.

Australian Mammals

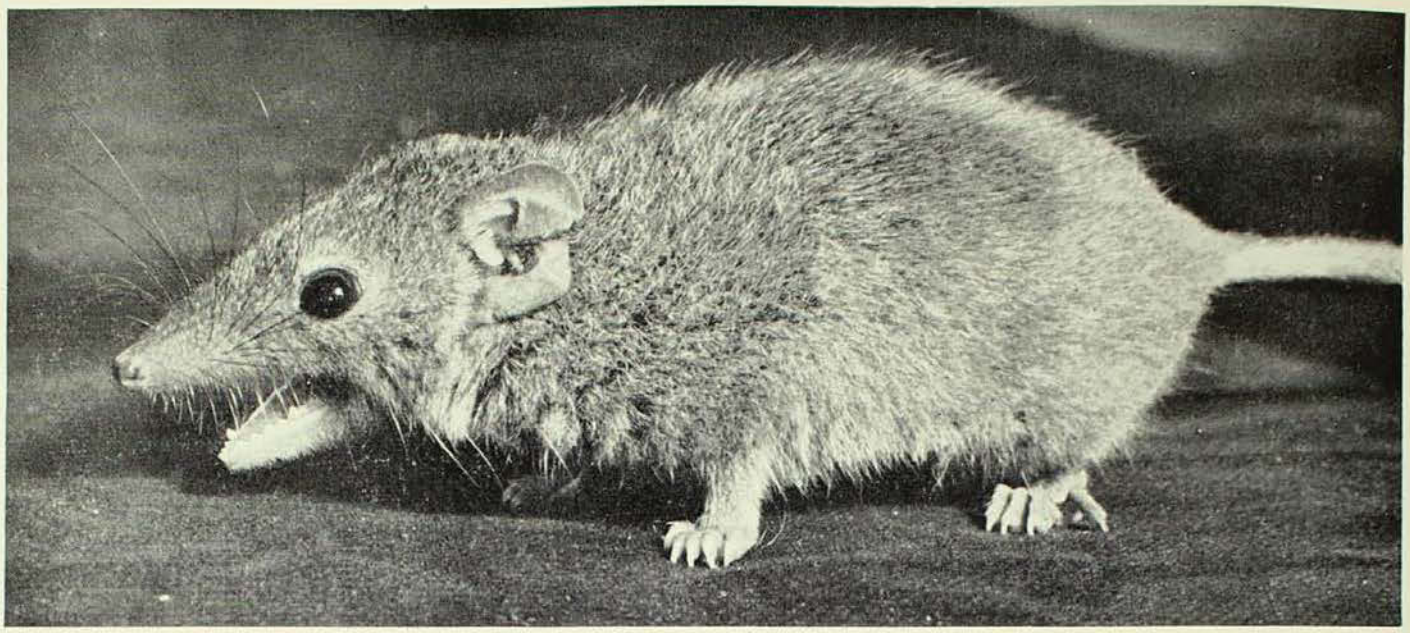
By A. G. LYNE

Division of Animal Health and Production, C.S.I.R.O., McMaster Animal Health Laboratory, Sydney

IT has often been said that the fauna of Australia is one of the most distinctive and interesting in the world. This is particularly true of the mammals, especially the monotremes and marsupials. The monotremes, unique in being the only egg-laying mammals known, are not found in any other part of the world. The marsupials, although represented in certain parts of America, have their stronghold in the Australian region where there is a great variety of highly peculiar forms.

The remaining mammals indigenous to Australia, the eutherian or higher mammals, are represented by the Aborigines, the dingo, a number of bats, a variety of rodents and various marine forms such as the seals, the whales and the dugong. No large land mammals, such as lions, tigers, elephants, rhinoceroses, camels, buffaloes, and many other groups which, in some form or another, are present in other parts of the world, are indigenous to Australia. Such of these as are present arrived through the agency of man.

The most primitive of all the orders of mammals—the monotremes—are entirely confined to Australia, including Tasmania, and New Guinea, and at the present time there is no definite evidence that members of this group have existed in any other part of the world. The living monotremes are the platypus or duck-bill (*Ornithorhynchus*) and the spiny ant-eaters or echidnas (*Tachyglossus* and *Zaglossus*). No intermediate forms between these highly specialized animals are known, and indeed, they so little resemble one another that their relatively close relationship would hardly be suspected. However, both these strange creatures lay eggs from which the young are subsequently hatched. The egg-laying character is considered to be a primitive heritage from ancestral reptiles, but the presence of hair, mammary glands, a diaphragm, as well as many other anatomical characters demonstrates that the monotremes are not reptiles but mammals. The echidna produces only one egg in a



Adult female yellow-footed marsupial mouse, *Antechinus flavipes*.

season; this it incubates in a temporarily-formed pouch into which the mammary glands open, and, after the young is hatched, it is carried in the pouch for some weeks. The platypus has no pouch; the two eggs usually produced are deposited in a burrow, where the young are hatched. In general gross external features the Australian echidnas resemble the true porcupines and hedgehogs of other continents but there is no close relationship.

The marsupials show an advance on the monotremes, in that before birth the young have already emerged from the egg, though they are less well developed at birth than is the case in the higher mammals.

Besides the well-known kangaroos, wallabies, phalangers (wrongly called opossums) and koala there are many other marsupials. Lesser known marsupials found only in the Australian region include the pouched mice (see illustration on this page), native cats, tiger cats, Tasmanian devil, Tasmanian tiger, wombats, rat-kangaroos and bandicoots (see illustrations on pages 121, 123, 124).

The American marsupials fall into two distinct families, the well-known true opossums (didelphids) of North, Central and South America, and the extraordinary rat-like marsupials (caenolestids) of South America.

It seems probable that America was the original home of the marsupials. Direct ancestors of the American opossums were present in North America in Upper Cretaceous times before the dinosaurs became extinct. Other fossil marsupials have been found in South America and in Europe.

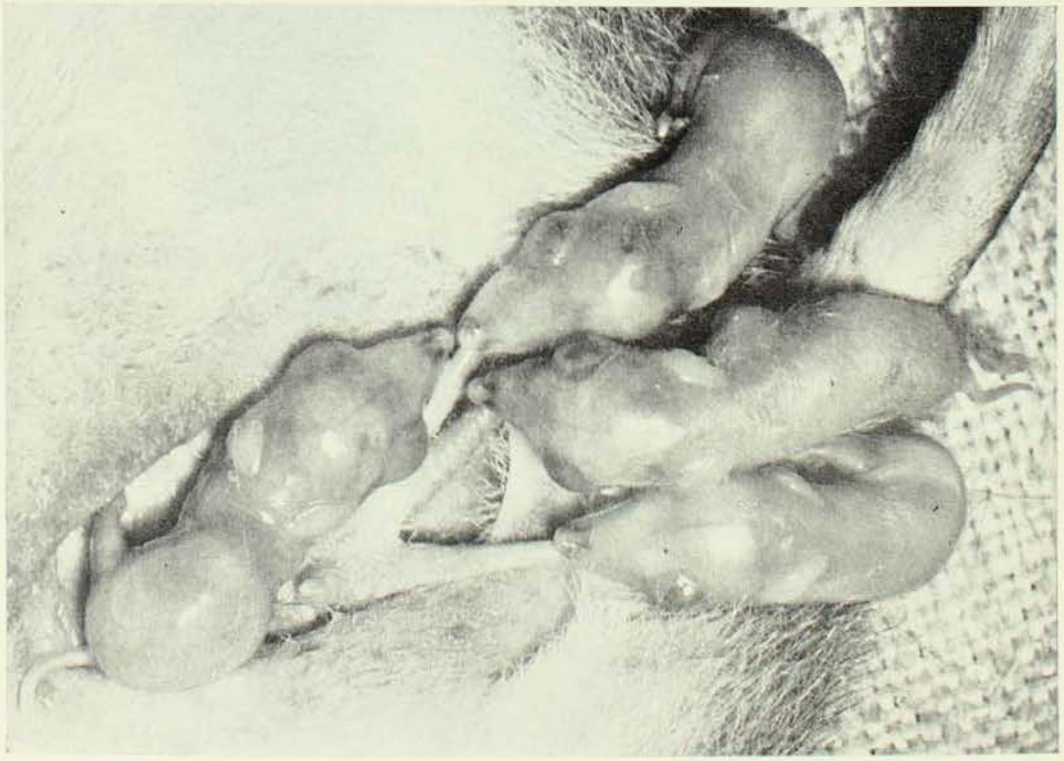
By which route did the ancestral marsupials reach Australia? Some authorities favour an entry from the north over a land chain which once connected Australia with Asia. The weak point of this theory is that no remains of ancient marsupials have yet been found in Asia. The opposing view is that the marsupials entered Australia from the south. Some of the living marsupials in Australia, particularly the Tasmanian tiger (*Thylacinus*), resemble some of the fossil marsupials (borhyaenids) of South America and it has been suggested that these two continents were connected at one time with the Antarctic continent, which at an earlier period must have had a milder climate.

The oldest known Australian marsupial, an extinct brush possum-like animal (*Wynyardia*), found near Wynyard, Northern Tasmania, belongs to either the Oligocene or Eocene period (these geological periods belong to Lower Tertiary times and the latter commenced about 60 million years ago). Improved methods for

determining the relative age of fossil bones have recently shown that in Victoria there were a number of different types of Tertiary marsupials, which may have extended over the whole of the continent. Fossil evidence also indicates that marsupials flourished during the Pleistocene which began less than a million years ago. During this period Australia was the realm of giant marsupials, such as *Diprotodon*, *Nototherium* and *Thylacoleo*. *Diprotodon*, the largest marsupial known, was as large as a rhinoceros. *Nototherium* reached the size of a bullock and *Thylacoleo* was about the size of a leopard. These huge marsupials have now disappeared just as many large eutherian mammals have in other parts of the world.

The marsupials have been able to adapt themselves to a great variety of widely differing modes of life and they have exploited practically every available ecological niche. Thus there are fossorial or burrowing forms—the marsupial mole (*Notoryctes*), the wombats (Vombatidae), and the rabbit bandicoots (*Macrotis*); terrestrial forms, like the rat-kangaroos, wallabies and kangaroos (Macropodidae), and the bandicoots (*Isoodon*, *Perameles* and *Choeropus*); arboreal forms—the phalangers (Phalangeridae), the koala (*Phascolarctos*) and tree-kangaroos (*Dendrolagus*); gliding forms—the volant phalangers (*Acrobates*, *Petaurus* and *Schoinobates*); and even an aquatic species (*Chironectes*) from South America. Marsupials may be insectivorous, carnivorous, herbivorous or omnivorous.

Many of the marsupials show a remarkable resemblance to certain of the higher mammals without being closely related to them. Popular recognition of this fact is recorded in such names as "Native bear", "Native cat", "Tiger cat", "Tasmanian tiger", and so on. An outstanding example is presented by the marsupial mole (*Notoryctes*) which in almost every external feature mimics the true moles (*Talpa*) and the golden mole (*Chrysochloris*) of South Africa. The marsupial mole is one of the most remarkable of the specialized marsupials. It has no eyes or external ears and it lives almost entirely underground. Of the many other examples available a few must suffice. The arboreal phalangers and the koala may be compared with arboreal lemurs, monkeys and sloths of other continents, and the gliding or volant phalangers may be compared with the flying squirrels. Some of the marsupial mice, bandicoots and wombats resemble some of the true rodents. The

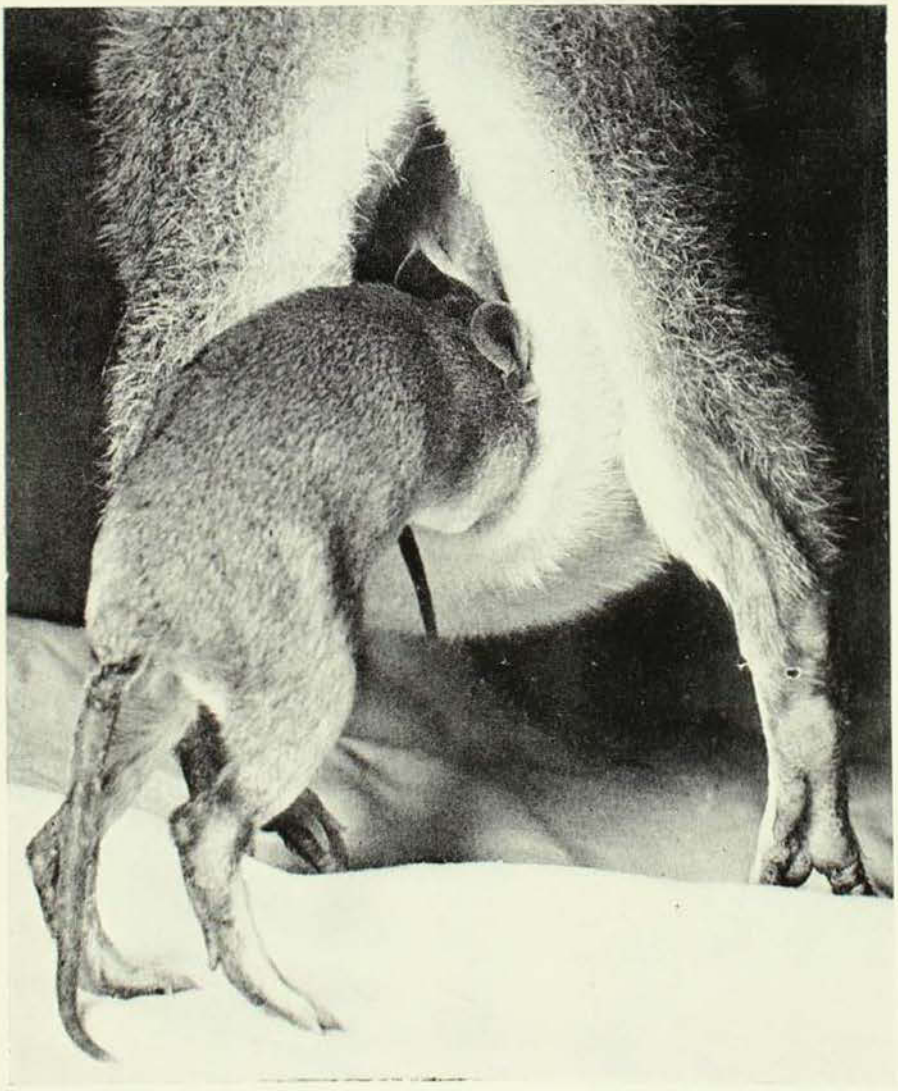


A litter of four young of the bandicoot, *Perameles nasuta*, outside the pouch about three weeks after birth. The greatly lengthened teats serve not only as milk ducts but also as tethers.

marsupial ant-eater (*Myrmecobius*), the marsupial honey eater (*Tarsipes*) and the pig-footed bandicoot (*Choeropus*) are among the marsupials showing extreme specialization. *Myrmecobius* for example, besides lacking the characteristic pouch, a feature shared with a number of other primitive marsupials, has a long tongue and a large number of teeth specially adapted for eating ants. *Tarsipes* is peculiar among the marsupials in that it feeds with its long tongue on the nectar of flowers. The remarkable pig-footed bandicoot has forefeet which resemble those of cloven-hoofed ungulates and hind-feet which show a rough similarity to solid-hoofed ungulates. Another highly specialized marsupial, the tree-kangaroo (*Dendrolagus*), has succeeded in re-adapting itself from a jumping, or saltatorial, to an arboreal existence.

Although precise information on the distribution of many of the Australian marsupials is lacking, it is known that a number of species, including some unique forms, like the Tasmanian tiger (*Thylacinus*) and the pig-footed bandicoot (*Choeropus*), have disappeared from many of their old haunts, and it may be too late to save them from extermination. Fortunately, however, most marsupials are now wholly protected by law and some species, for example, the koala (*Phascolarctos*), are said to be increasing in number after being almost on the verge of extinction.

The interest attached to the monotremes and marsupials has appealed to the naturalist so strongly that he has generally neglected to pay much attention to the native, or indigenous, eutherian mammals. In fact, it is a popular error to suppose that



Young bandicoot (*Perameles nasuta*) about 8 weeks old entering its mother's pouch, which opens downwards and backwards.

The cover photograph and the photographs in this article were taken under the author's direction by Mr. I. T. Roper, McMaster Laboratory, C.S.I.R.O., Sydney.

all indigenous Australian mammals are monotremes or marsupials. Before the coming of the white man the eutherian mammals were represented by a number of different orders which seem to have entered the continent at different times. Perhaps among the first eutherians to arrive were the true rodents (rats and mice), which may have entered Australia from the north and spread southward. From the remains of various rodents found in company with the bones of marsupials which have since become extinct, it is known that the native rodents must have reached Australia a long time ago. The specialization of many of the Australian rodents also indicates that they have been long established. One of the most remarkable is the water rat (*Hydromys*). Other interesting Australian rodents include the hopping jerboa-like rats and mice, and the house-building rats. Such rodents as the rabbit and the hare, the black rat, brown rat and house mouse, have all been introduced by the white man.

The dingo, or native dog, is a true eutherian carnivore which is widely distributed in Australia, although it never reached Tasmania. It is an old inhabitant of Australia for its remains have been found mixed with the bones of extinct marsupials in Pleistocene deposits. There is some evidence to suggest that the dingo was brought into Australia by the aborigines who must have arrived many thousands of years ago.

Australia contains a considerable number of bats of various kinds. The largest of these are the widely-distributed fruit-eating bats or flying foxes. A number of species of the insectivorous bats are represented in Australia, a few forms widely distributed but the remainder confined to the continent.

Various representatives of the seals (Pinnipedea) are found around the Australian coast. One of the most interesting of the marine mammals, the dugong of northern coastal waters, belongs to the eutherian order of sirenian mammals. Most of the truely aquatic cetacean mammals (whales and dolphins), seen in Australian waters at certain times of the year, are common to all the southern oceans.

Retirement of Mr. J. R. Kinghorn

The Curator of Birds, Reptiles and Amphibians, Mr. J. R. Kinghorn, who has been Assistant to the Director since 1941, retired in October after almost fifty years of service. His appointment in 1907 as a Scientific Cadet was in accordance with a staff plan recommended by a professorial committee of Trustees, in consultation with the Director, Robert Etheridge, previously of the British Museum. The cadets' curriculum included specialized studies, curatorial training, and field-work in zoology. In 1914, while in charge of the spirit-preserved collections, Mr. Kinghorn resigned when appointed as Zoologist on the Federal Investigation Ship *Endeavour*, lost at sea prior to his taking duty abroad.

Rejoining the scientific staff as Junior Assistant in 1915, Mr. Kinghorn served with the 1st A.I.F. in the Anzac operational area, and was invalided from France in 1918, a period of service renewed with the Home Forces in World War II. In August, 1918, he was given curatorial charge of Herpetology (reptiles and amphibians), subsequently combined with his Curatorship of Ornithology. Research in these subjects produced a long list of scientific and popular writings, including the book *Snakes of Australia*, revised for republication this November. A war-time booklet on *Dangerous Snakes of the South-West Pacific Area* was published in collaboration with Dr. C. H. Kellaway, then Director of the Walter and Eliza Hall Institute. More recently, articles on reptiles and amphibia have been revised for the new edition of the *Australian Encyclopaedia*.

In 1937-8, under a Carnegie Corporation grant, Mr. Kinghorn visited the leading museums of America, Great Britain, and Europe. He holds the Diploma of the Museums' Association of Great Britain, was elected a Corresponding Member of the Zoological Society of London in 1928 and is also a Fellow of the California Academy of Sciences. A fellow of the Royal Zoological Society of N.S.W., Mr. Kinghorn has just completed a second term as President of that Society. In this office, and through many avenues as a lecturer, and broadcaster in school and nature sessions, he has been a keen advocate of conservation, and has been the Museum's representative on the Fauna Protection Panel of the State since its inception in 1949 E. LE G.T.

Australian Birds

By ALLEN KEAST

SIX hundred and fifty-one different species of birds occur in Australia. Of these, 83 are visitors that do not breed on the continent and 37 are seabirds that nest on islands off the coast. This leaves a total of 531 species of breeding land and freshwater birds for the Australian Continent—fewer than on the tropical island of New Guinea to the north (some 566 species).*

Australia has less bird species than any of the other continents (it is also the smallest), as will be seen from the following figures:—

Australia	531
Africa	1,750
South America	2,500
North America	750
Europe and Asia.. ..	1,110

Notwithstanding numerical limitations, however, the birds of Australia are remarkably diverse and interesting. There is a good proportion of unique forms. Moreover, Australian birds rival any in coloration and are at least equal to the other continental faunas in song, as an American authority in this field, Dr. Charles Hartshorne, has recently stressed.

Australia has two large flightless birds, the Emu and the Cassowary, second only to the Ostrich in size and weight. We have the world's only black swan—small wonder that it created a sensation when first taken to Europe! Birds that do not hatch their eggs by incubating, in the manner of other birds, but let the heat of the sun and of decaying vegetation do it for them, are confined to Australia and the adjacent Pacific islands. There are three species of these in Australia (Mallee Hen, Jungle Fowl, Scrub Turkey) and they spend much of the year scraping together the huge mounds of earth and forest litter that are to be their incubators. And Australia has a whole family of birds, the honeyeaters (some 60 species), whose tongue is modified into a tiny brush for sweeping up the nectar (their favourite food) from the flowering shrubs and trees that are such a feature of our countryside.

The Lyrebird has been called, and with good reason, the world's greatest mimic. At the height of its winter concerts the Lyrebird mimics the call-notes of up to 20 other species plus, on occasions, a whole miscellanea of forest noises, from the crosscut saw to the ringing axe. Some of these sounds are so real that they have fooled many a bush visitor. Lyrebirds scrape together earthen dancing mounds and it is there, as the male struts about with his magnificent tail elevated, that the singing is done. Lyrebirds, and their smaller relatives the Scrub-birds, belong to quite an ancient group and one of the scientifically interesting things about them is that they have a peculiar breast-bone.

In terms of behaviour the bowerbirds of Australia are perhaps the most highly developed of all birds. The male bowerbird builds a display "bower" of sticks, of variable shape but commonly consisting of two parallel walls of sticks surrounded by a wide clearing adorned with various "playthings". The Satin Bowerbird of eastern Australia has a mania for blue and pale yellow objects and scattered around its playground one finds feathers and flowers of these colours, and a whole variety of "civilized" articles scrounged from the roadside, picnic areas, and about homes: blue cigarette packets, blue plastic toys and marbles, old laundry "blue bags" and so on. But perhaps the most unusual fact known about the Satin Bowerbird is that it has been recorded actually painting the walls of the bower, applying macerated charcoal with the aid of a wad of chewed-up bark.

A feature of Australian avifauna is that many families of birds, known in Europe by only one or two species, "blossom out" here into a whole series of forms. Foremost amongst these are the parrots, of

* See Mayr and Serventy, *The Emu* XLIV, p. 33.

Male Lyrebird, with tail folded, preparing a new mound by vigorous scratching.

Photo.—R. T. Littlejohns.

which Australia has 50-odd species. They range from giant black cockatoos, perhaps twice the size of a crow, down to little fig-parrots the size of a sparrow. Nowhere else do parrots reach such a degree of beauty as in Australia. The rosellas look as if they have been splashed with the rainbow's most brilliant colours and others are a delicate symphony of the most subtle pastels. What could leave a more vivid impression than a flock of galahs against the blue sky, pink one minute and, as they turn, a scintillating silver mass? The spectacular reaches its peak in the great parties of white cockatoos and corellas over the inland plains, and in the groups of Gang-gangs, the brilliant red heads of the males standing out from their dark grey bodies, as the birds sweep through the jagged gorges of the mountains. Australian parrots are fully as diverse in foods as in habit and colour. Some are specialized for digging grubs out of tree trunks, others for getting seeds from the ground or branches, others again for extracting nectar from the flowers of the eucalypts, or taking wild fruits in the jungles of the east.

The European knows only one cuckoo; Australia has no fewer than 12 species. Instead of one species of kingfisher we have 10. There are 9 owls, 10 quails, 24 hawks and eagles (our Wedge-tailed Eagle is very closely related to the Golden Eagle of Europe and North America), 19 different ducks and geese, and no fewer than 23 pigeons and doves.

Most of our national favourites occur nowhere but in Australia. The kookaburra, the world's largest kingfisher, does not seek its food from water but lives in the forest. Its laughing call-note is reason enough for fame but an unchallenged reputation as a snake-killer endears it to every outdoorsman. The Australian magpie, quite unrelated to the bird of that name from the Northern Hemisphere

Male Satin Bowerbird at its bower.

Photo.—Roy P. Cooper.

(though it is black-and-white) is a delightful songster and its carolling is a feature of spring mornings. Magpies are resolute defenders of their nests and woebetide any thoughtless person who unthinkingly walks beneath them.

The birds of Australia, like those elsewhere, are specialized in their choice of living places. Many are confined to the denser coastal forests, others to rain forest, marshes, the plains of the inland, or the desert itself. What effect then has settlement had on the avifauna? In some cases it has been severe but in others, believe it or not, it has led to a marked increase in numbers of the species. Into the former category come the large fruit pigeons, the edible Scrub Turkey and Jungle Fowl, for these are inhabitants of the tropical rain forest—and rain forest is a wonderful source of soft-wood timber. The introduction of sheep—and that all too familiar scourge, the rabbit—has materially altered great areas of the continent. Tall, lank, grasses, have been replaced by stubble and eroded areas, leading to a decline and falling away of quail and finches. The clearing of the mallee has seriously reduced that other mound-building bird, the Mallee Fowl. The species that have gained materially in numbers are the inhabitants of open fields: Magpies, Peewees, Ground Larks, and others. There is, however, no denying the immensity of the problem facing authorities endeavouring to create national parks to safeguard our unique fauna from extinction. It is not merely a question of setting up such parks and ensuring that they are of sufficient size—they must contain all the different types of animal habitat and even now the habitats of different animals, and what it is that keeps them there, are poorly known.

Australian Insects

By J. W. EVANS

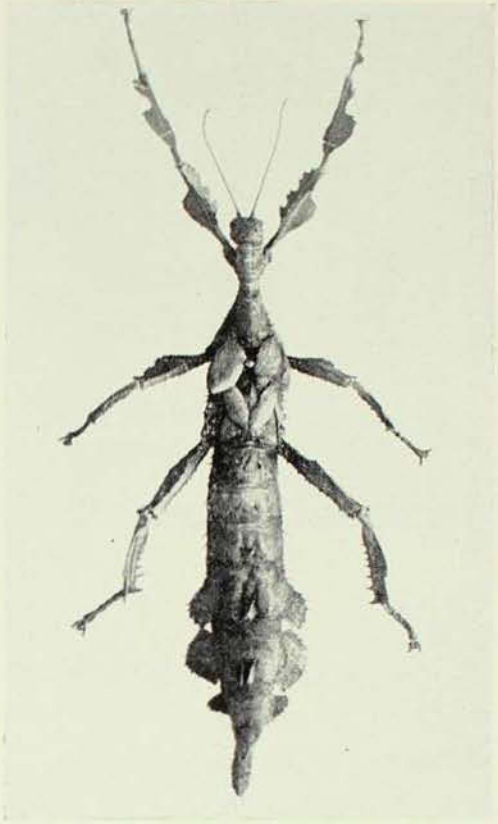
THERE is no other country in the world which can compare with Australia in so far as the interest of its insects is concerned. Here there are to be found survivors from distant geological periods when Australia was linked by land with other continents, abundant forms which developed their special characteristics during the millions of years when the continent was isolated from the rest of the world, and brilliant tropical insects that have reached Australia from the north in, geologically speaking, comparatively recent times. Not only are living Australian insects of extreme interest but so also are extinct ones, since some of the finest fossil insects known to science have been discovered in New South Wales and Queensland.

There are more kinds of insects than of all other land animals put together and obviously only a few can be mentioned in a short article. Those which have been selected represent some of the many Australian ones which are of outstanding interest.

DRAGONFLIES

Dragonflies are known to everyone because of their large size, swift flight and irridescent wings. They feed on other insects, both in their adult winged and aquatic larval stages.

The dragonfly fauna of Australia is a rich one and is reasonably well known. One of the most interesting species is a small, brilliant metallic green insect (*Hemiphlebia mirabilis*) which is the only dragonfly living to-day to have retained certain features characteristic of extinct forms which lived in the Permian period, some 200 million years ago. So far, this insect has been found only in two localities, one of which is in Queensland (Port Denison) and the other in Victoria (Alexandra).



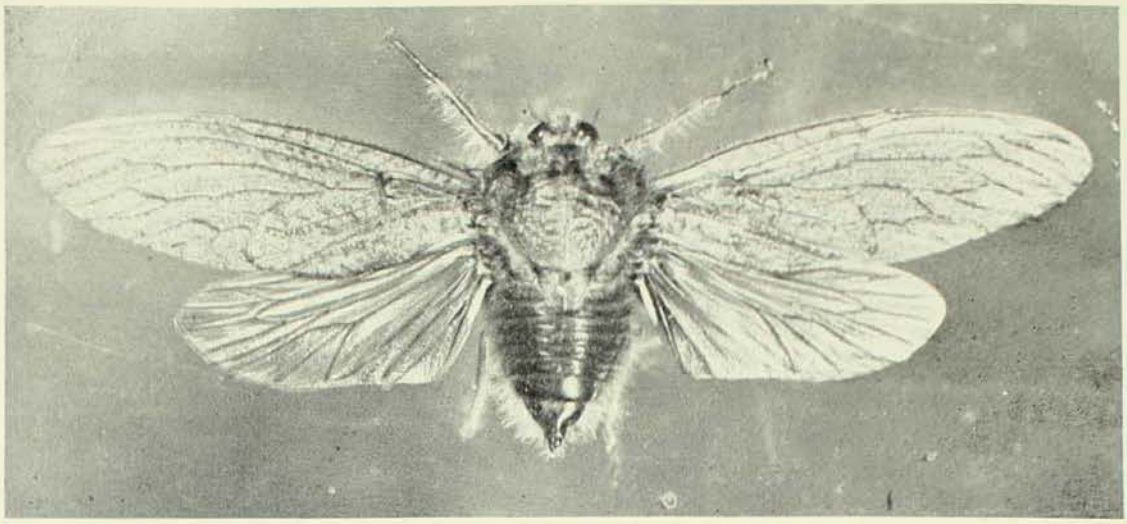
The female of the Spiny Leaf Insect (*Exatosoma tiaratum*).

Photo.—G. C. Clutton.

TERMITES

Termites are popularly, though incorrectly, known as "white ants". Other groups of insects have developed social communities, but those of termites are by far the oldest, largest and most complex. Their colonies comprise several forms, or castes, which include blind "workers" which make the nest and have other duties; large-headed "soldiers" which defend the nest; the sexual, or winged, caste and the "royal pair". In comparison with other inhabitants of a nest, the queen may be enormous in size.

Very large termite mounds occur in Northern Queensland and those made by representatives of some species may be 15 feet or more in height. Also in Queensland, and northern Australia generally, lives the Giant Termite (*Mastotermes darwiniensis*). This is the largest and most primitive termite in the world and is at the same time the most destructive species in Australia,



The Hairy Cicada (*Tettigarcta crinita*).

not only causing damage to woodwork in buildings but being also injurious in other respects.

LEAF AND STICK INSECTS

Leaf and stick insects are of particular interest because of their remarkable resemblance to parts of plants and because some are very big insects of striking coloration. A few Australian species are among the largest representatives of their group in the world and may be as long as 10 inches, with a wing span of similar length. The most remarkable Australian species (*Exatosoma tiaratum*) is about 5 inches long. It is green in colour and has dilated spiny leaf-like processes on its legs which render it almost invisible when resting on a plant. The female has reduced functionless wings and is heavy-bodied, while the male has fully developed wings and is slender in shape.

STONEFLIES

Although some Australian stoneflies are of great beauty, they are probably seldom noticed by the ordinary observer. Stoneflies pass their larval stages in running water and the adult insects are mostly small drab creatures which carry their wings folded closely over their bodies. The hind wings of representatives of one family of large stoneflies (Eusthenidae) are a brilliant crimson, scarlet or purple. In Australia, this family occurs in Tasmania and Victoria, and elsewhere only in cool-temperate South America. It is thus one of the many ancient groups of Australian insects which provide evidence of the former existence of a large southern continent of which Australia, Antarctica and South America formed part.

THRIPS

Although thrips are minute insects, nevertheless they are well known since one native species (*Thrips imaginis*) sometimes occurs in enormous numbers and causes injury to fruit and other blossom.

The largest thrips in the world (*Idolothrips spectrum*) is an Australian species. It varies in size, but may be as long as half an inch. In colour, it is dark-brown or black and it occurs very commonly in the bush.

SUCKING BUGS

The term "bug" is often applied to an Order of Insects (Hemiptera) of which all representatives feed by piercing and sucking. Cicadas, or as they are popularly called "locusts", belong to this order. Because of their large size and vocal prowess, cicadas are well known to every Australian, and most know that they pass their immature stages below ground, feeding on roots.

By far the most ancient Cicada living in the world to-day (*Tettigarcta*) occurs only in Australia. Its nearest relatives are not to be found among living forms; they are known only as fossils of the Permian period. The sound of this cicada has not been heard and it may well be inaudible to the

human ear, but almost certainly it can produce sound. Futhermore, it is probable that, unlike other cicadas of which only the male can make a noise, both sexes can "sing".

BEETLES

Beetles range in size from minute to very large insects and their food and habits are amazingly varied. The most beautiful ones belong to a family known as "Jewel Beetles" (Buprestidae) which are particularly well represented in Australia, many hundreds of species having been described. Some Jewel Beetles are small, but others are nearly two inches long. In colour they may be scarlet, golden, purple or metallic green, or a combination of several colours. Their larvae feed in the wood of living trees.

ANTS

Everyone with even the slightest acquaintance with the bush is aware that ants are abundant in Australia. They will be familiar also with the dreaded "bull-dog" ant (*Myrmecia gulosa*) which like other species in the genus *Myrmecia*, will attack on the slightest provocation and inflict severe pain by both stinging and biting. This ant is the largest in the world, and may be as long as an inch. Also in Australia there occurs the most archaic ant in the world (*Nothomyrmecia macrops*) known only from Western Australia.

SCORPION FLIES

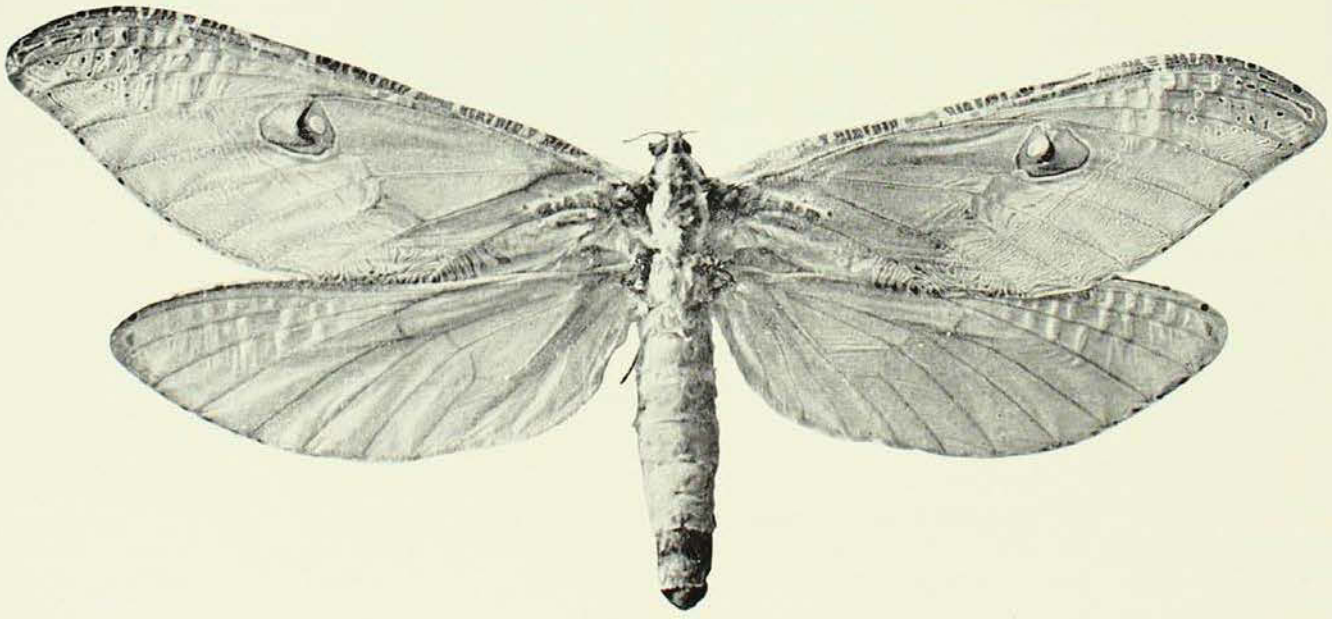
Scorpion Flies (Mecoptera) are well known only to entomologists. They derive their name from the bulbous termination of the bodies of the males of some species.

Both the adult and the larvae, which are caterpillar-like in appearance, feed on live and dead insects and some feed on plants. Many interesting kinds occur in Australia, and the most interesting of all (*Austromerope poultoni*) is known from a single specimen found in Western Australia. It belongs to an ancient group of scorpion flies of which there are only two other representatives. One of these (*Merope tuber*) occurs in North America, while the other (*Notiothauma reedi*) lives in Chile.

FLIES

Flies (Diptera) differ from other insects in having one pair of wings instead of two.

Most luminous insects whether known as "fire flies" or "glow-worms" are beetles, but there is a genus of flies (*Arachnocampa*) occurring in Australia and New



The Bent-wing Moth (*Leto staceyi*).

Photo.—G. C. Clutton.

Zealand which has larvae which emit light from the apical segments of their bodies. These larvae live, particularly, but not solely, in caves entered by creeks and feed on other insects which become entangled in hanging threads of their salivary secretions. Although best known from the Waitomo caves in New Zealand, these luminous larvae occur also in caves in Tasmania, such as in those at Ida Bay.

CADDIS FLIES

Caddis Flies are moth-like insects which pass their larval stages in fresh water, and their larvae live in protective cases made of sticks, stones or other debris.

There is a single caddis fly (*Philanisus plebeius*) of which the larvae inhabit rock pools containing sea-water and make their cases of coralline sea-weed. This species is known from New Zealand and from the coast of New South Wales.

BUTTERFLIES AND MOTHS

Australia has an abundance of splendid butterflies and moths but space permits two only to be mentioned. One is the Regent Skipper (*Euschemon rafflesia*) which differs from all other butterflies in the nature of its wing-coupling apparatus. The other is the Bent-wing moth (*Leto staceyi*). This is a large, magnificent insect, orange brown in colour, with silvery markings and an eye spot on its forewings. It belongs to a family (Hepialidae) of ancient moths which is particularly well represented in this continent. The larvae of most feed in living timber.

At the beginning of this article mention was made of the supreme interest of Australian insects. Compared with those of the Northern Hemisphere they are still but little known and offer a challenge to all naturalists who have the privilege of living in this fascinating continent.

The Great Barrier Reef

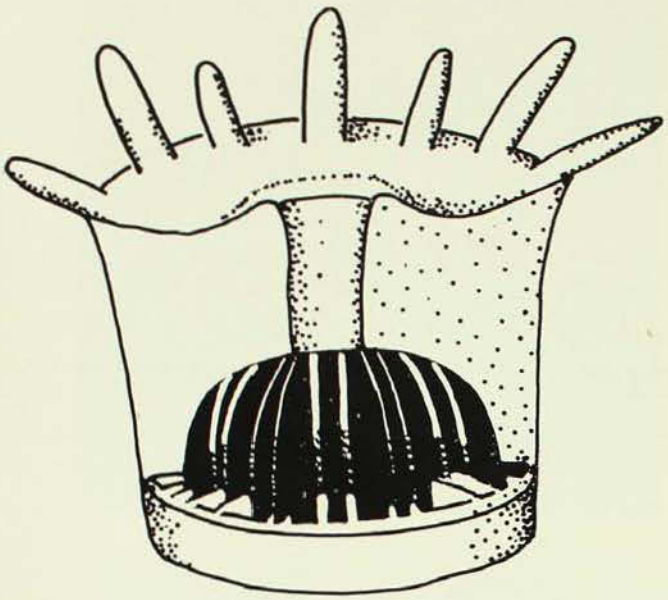
By W. STEPHENSON

Department of Zoology, University of Queensland

THE Great Barrier Reef of Queensland is the only considerable area of the globe visible to the human eye which is dominated by animals rather than plants. The reefs are formed by corals and by other less important organisms, and are of great interest to zoologists, geologists and geographers from all over the world. In this article we will approach the reefs from the zoological standpoint, in the belief that knowledge of the animals producing the reefs is essential to the understanding of all other aspects.

The term "corals" is sometimes applied to the skeletons of living animals, and sometimes to the living animals with their contained skeletons. These animals belong to a group—the Coelenterates—containing the sea firs, jellyfish, and sea anemones in which the basic plan of the body is extremely simple. It consists merely of a two-layer sac, containing a central cavity in which food is digested. (See text figure.)

The corals have two complications which the sea anemones do not possess. The first is the secretion of calcareous material (limestone) within their tissues, and the second is the tendency to form colonies. In some corals the calcareous material consists merely of scattered nodules, which give little or no strength to the mass. These are the soft corals (Plate I, a, b) so called because their bodies are either soft and slimy to the touch or at most feel gelatinous. Although abundant on parts of the Great Barrier Reefs they play no spectacular role in the building up of these reefs, although after death the nodules must add something to the general bulk.



In corals partitions run from the walls of a two-layer sac into the central space, to increase the digestive area. The number and intricacy of these partitions can obscure the basic simplicity of the plan.

In other corals—the true or stony corals—the calcareous material is knitted together to form a single mass of limestone, either in the form of a solid or perforated mass. This limestone is laid down between the sac-like individual animals, and also in the partitions which partly obliterate the sacs. Some of the beauty of coral skeletons is the intricacy and faithfulness with which they follow the lines of these partitions (Plate I e).

Colony formation is another characteristic of both the soft and hard corals. Some of the stony corals are solitary (*e.g.*, *Fungia* the Mushroom Coral—Plate I e) but the vast majority are formed by the budding of an original sac-like animal, whose daughters remain attached, grow, and bud again. The budding process can be seen clearly in many species of corals (see Plate I f) and is important in producing large living units, and so large limestone masses.

Although corals occur in cold waters, the large luxuriantly growing masses occur only in warm waters. The distribution of coral formations through the waters of the globe is clearly related to high temperatures. One of the reasons why the Great Barrier occurs off the north-east of Australia rather than the north-west is that the eastern coastline is bathed by the warm southwards flowing Notonectian current.

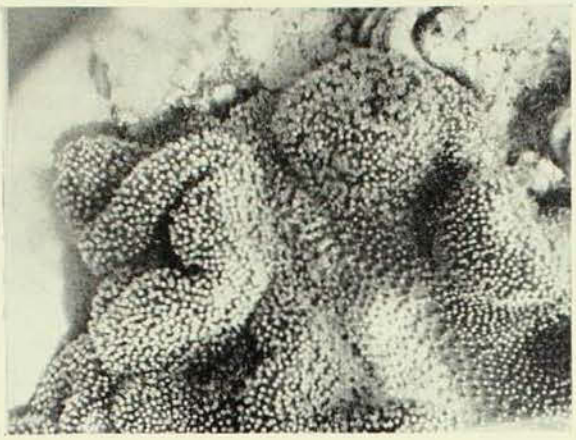
In addition to high temperatures, the depth of water has important effects. Corals grow more luxuriantly in shallow than in deep water, and the operative factor seems to be light. The action of light on corals is a strange story; it acts upon plant cells *within the coral tissues*. These plants are not parasites, because the association is of benefit to both animals and plants. The most important benefit to the animals seems to be that, in sunlight, the plants remove carbon-dioxide and supply oxygen to the tissues. It seems likely that this association of mutual assistance has been one of the prime factors which have enabled the corals to become such a significant animal group.

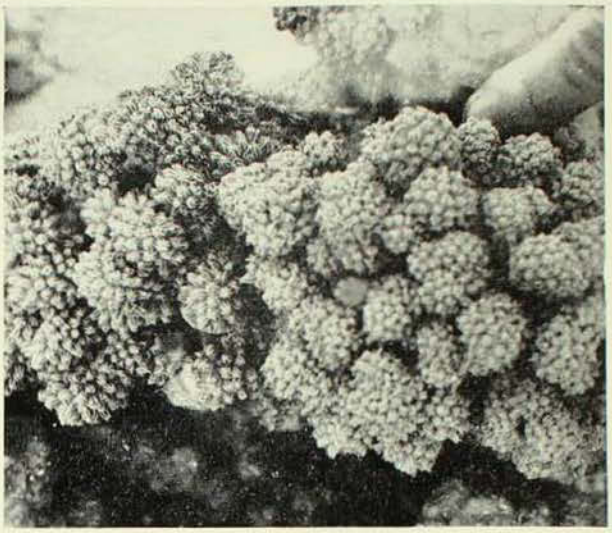
Corals grow upwards from water of moderate depths into the shallows, and as they do so some species become less common. Other species increase in abundance, building up from and eventually smothering the deeper species. Much is yet to be learned of this process, and data is not easy to obtain. Dredging is very difficult; underwater observations by aqualung seem to be the best line of approach.

When they reach near the surface, coral growths become a navigational hazard, and information upon growth rates is not merely of zoological and geological interest but of prime interest to the navigator. Once again data is scanty. We know in general terms that the massive hemispherical species which form "niggerheads" grow much more slowly than such fragile branching forms as the staghorn (*Acropora* spp. Plate II a). We do not know the varied growth rates of different species of staghorns in natural conditions, but believe that the average rate (which means very little) is something like an inch a year.

The upward growth of corals is eventually arrested, probably by a variety of factors whose importance varies from place to place. Exposure to the drying effects of the air is almost certainly important. Many corals can live up to just above the level of low water of spring tides, where they are

(a)





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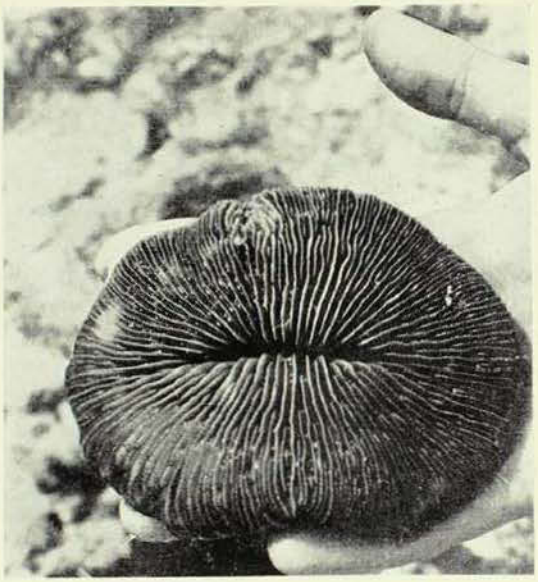

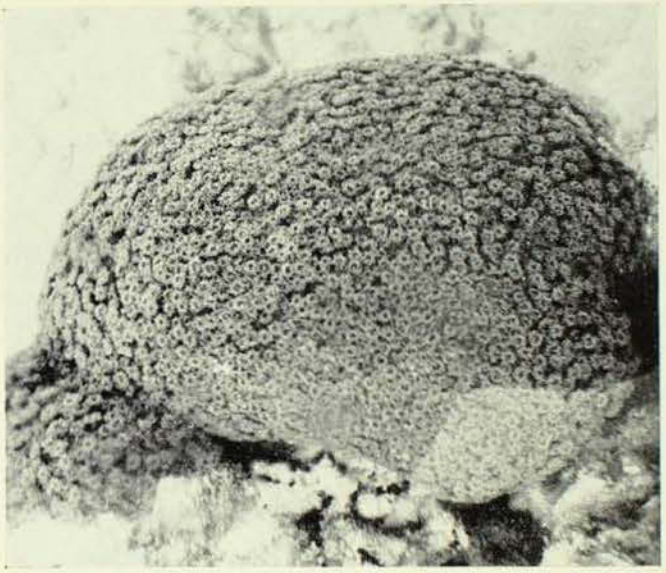

(d)

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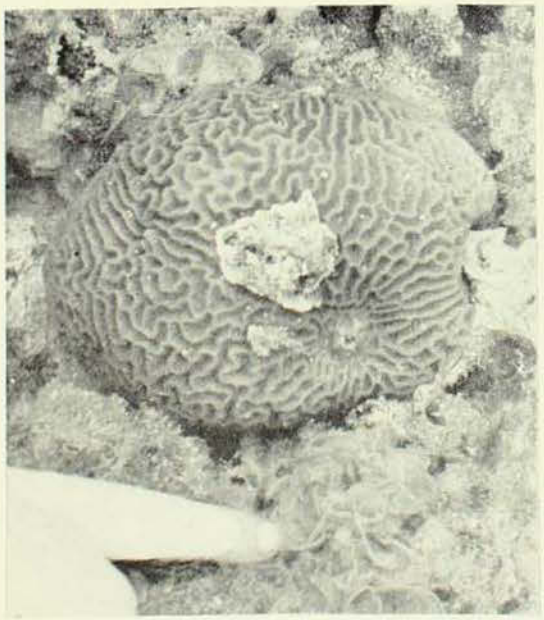
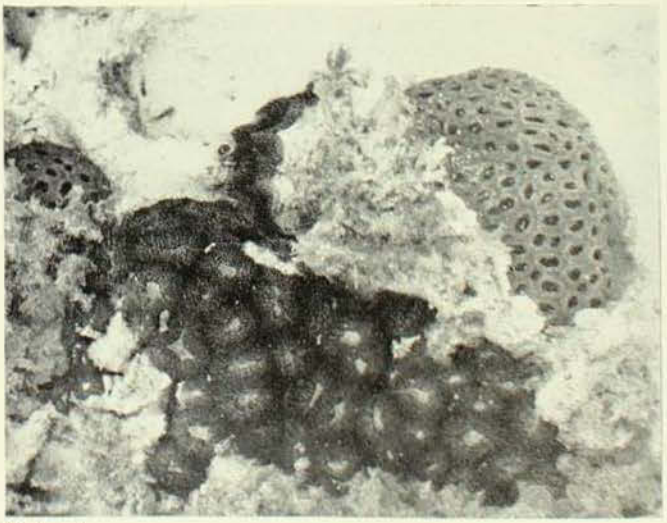




(f)

Plate I.

(a) and (b).—Soft corals from the reef flat at Heron Island; each of the minute "pimples" is a small sea-anemone-like animal. (c), (d), (e) and (f).—Living stony corals from the reef flat at Heron Island: (c) *Fungia*—a solitary Mushroom coral showing the partitions which divide up the sac-like space within the animal. (d) *Goniopora*—one of the few corals in which the individuals are expanded in daytime. (e) *Platygyra*—a small brain coral with elongate wandering individuals. The finger points to a brown seaweed. (f) A dark colony of partly expanded individuals (*Symphyllia*—the horse's tooth coral) several of which are in process of budding, and also two lighter colonies (of *Favia*).

Photos.—Author.

only exposed for one or two hours every fortnight (Plate II c). None can live above the level of low water of neap tides where they would be exposed daily. Rock pools are an exception, but here the exposure factor is eliminated.

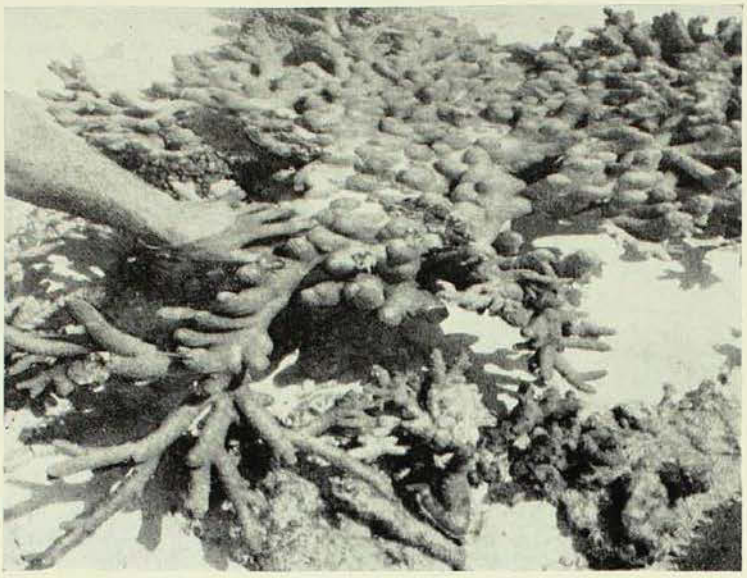
Freshwater flooding is another factor which operates in shallow water. The most graphic demonstration ever recorded was the effect of the floods which accompanied the great 1918 cyclone in the Bowen region. Freshwater poured out over the sea, and formed a separate layer, which came in contact with the corals at every low water. Corals were killed and destroyed over a wide area, spreading out as far as Hayman Island. Something of the same sort of thing seems to have happened in early 1956 at Peel Island in Moreton Bay, where there is the most southerly coral-dominated situation near the eastern Australian mainland. In this especially wet summer corals high up the beaches have been destroyed, seemingly by freshwater, apparently in drainage channels from the upper beach. This is an especially interesting case because one might suspect that low temperatures were limiting corals in this southerly locality. Low temperature cannot be the cause because the deaths occurred in late summer.

Wave action also becomes important as the corals approach the surface. Two different aspects seem to be involved, firstly the effect of more or less steady conditions, and secondly the effects of extreme conditions. Where the surf beats almost all the time corals form flat encrusting growths (see Plate II b) but where conditions are calmer either from shelter or from increasing depths, the characteristic growth forms are erect or foliaceous (Plate II a). In part the differences are due to different species growing in the contrasting conditions, and in part because a given species can exhibit different growth forms.

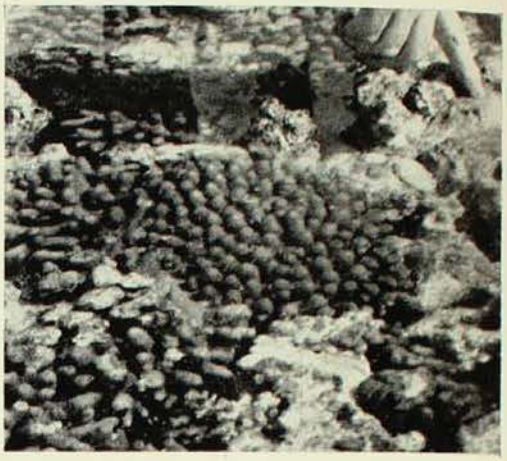
Extreme wave action is characteristic of cyclones, and studies of their effects are being actively pursued in Queensland. The immense power of cyclone-generated waves can lift huge masses of living coral from shallow water, and deposit them above low water mark. Thus originate the boulders of coral rock which are strewn on reef crests along the Barrier Reef (Plate II e). Branching masses are broken, and thrown upwards. The "coral stick shingle" beaches of Northern Queensland are derived in this fashion. Once material is thrown up on high there is a possibility that, by continual aggregation, an island may be formed. In North Queensland, near the mainland, coral shingle is colonised by mangroves and yet further building up can occur (Plate II d).

Meanwhile, if a sizeable mass of coral reaches low water mark and then grows horizontally (as it must) a big flat platform can be formed. The centres of these platforms are lower than their edges and while the causes are still under dispute, the effect is that lagoons or reef flats are produced. Reef flats contain extensive areas of gritty sand which accumulates on the flats towards the lee side, and forms sand-banks. If these sand-banks remain for a sufficient period they are colonised by terrestrial vegetation, including Pisonia trees, Screw pines (*Pandanus*), and Sheoaks (*Casuarina*). In this way coral cays are built up.

A great deal remains to be discovered about corals and the structures they produce. The agents or conditions responsible for the hollowing out of lagoons or reef flats (if in fact they are hollowed out) still need elucidation. The effects of cyclones are still a matter for conjecture because the effects of severe wave action are complicated by coincident effects of rainfall and flooding. It has been suggested that land clearance has increased the severity of floods and will result in a progressive decline in coral abundance in the inshore waters of northern Queensland. Once again this cannot be accepted at its face value without further work. The factors responsible for the controlling of the size of coral cays are still doubtful, and will no doubt involve detailed studies of animals and of water currents. Many of these problems seem academic and doubtless they are, but they are of such widespread interest that one would wish for more serious endeavour in this direction.



(a)



(b)

(d)

(c)

(e)

Plate II.

(a) Living staghorn coral (*Acropora*) from the reef flat at Heron Island. (b) Stunted growths of staghorns near the reef edge at Heron Island. (c) Living coral (*Montipora* and *Acropora*) at low water springs, Low Island near Port Douglas. (d) Coral shingle and mangroves at Low Island. (e) Coral boulder ("nigger-head") at Low Island.

Photos.—Author, and E. Hollywood, University of Queensland photographer.

Other problems are far from academic. At least one of our famous island tourist resorts is on a coral cay which is getting smaller at a visible rate and may disappear in a period which would be negligible on a geological time scale. Other problems concern the possible utilization of coral limestone for economic purposes without detriment to a rich natural heritage. Yet others concern the possible increase of fishing activities, which casual observation suggests could be vastly increased.

Work on many of these aspects is proceeding at the present time on the Great Barrier Reef, but at a rate which is a pitiful tribute to our national pride in a unique natural phenomenon.