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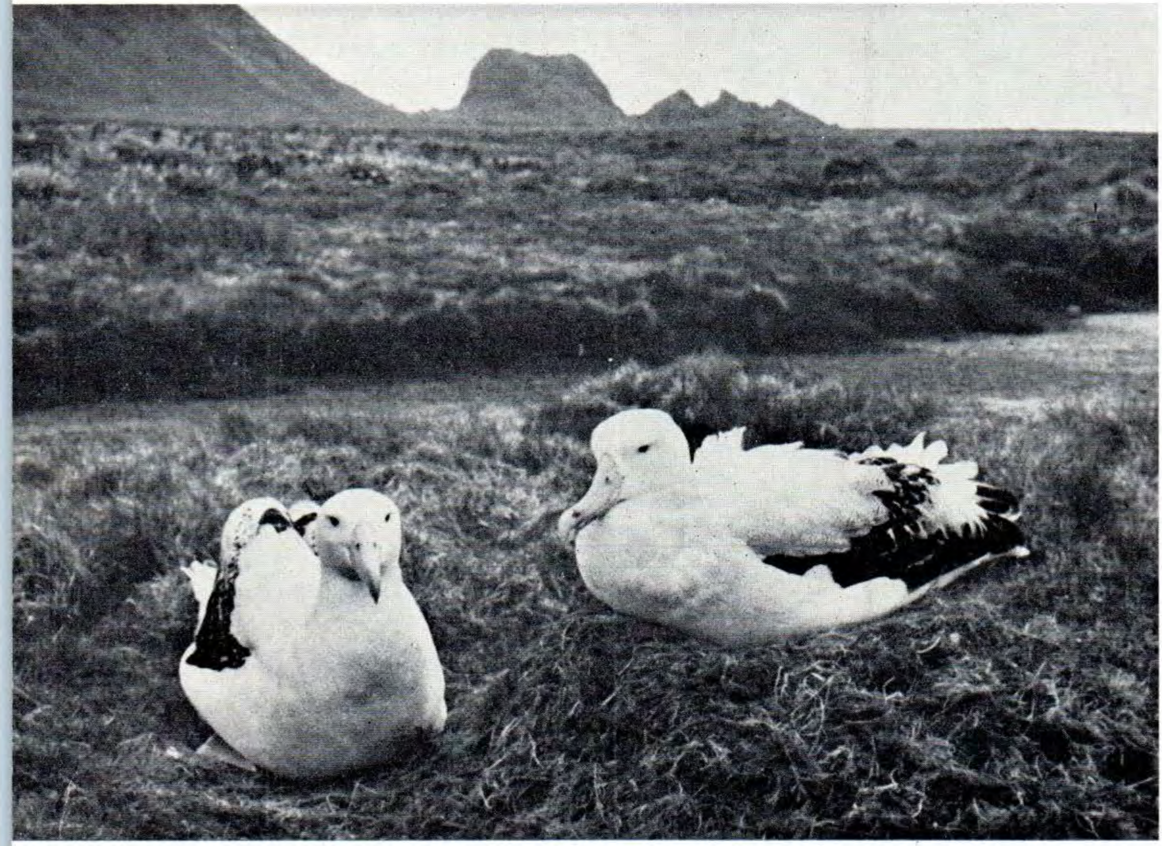

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● FRONT COVER: A pair of Wandering Albatrosses nesting on Macquarie Island. The female bird (right) is sitting on the nest. This photo was taken by M. D. Murray, whose article, "The Wandering Albatross, A Brief Review of Studies in Progress," appears on page 75.

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The Burrowing Shore Crab of Southern Australia

By R. W. GEORGE

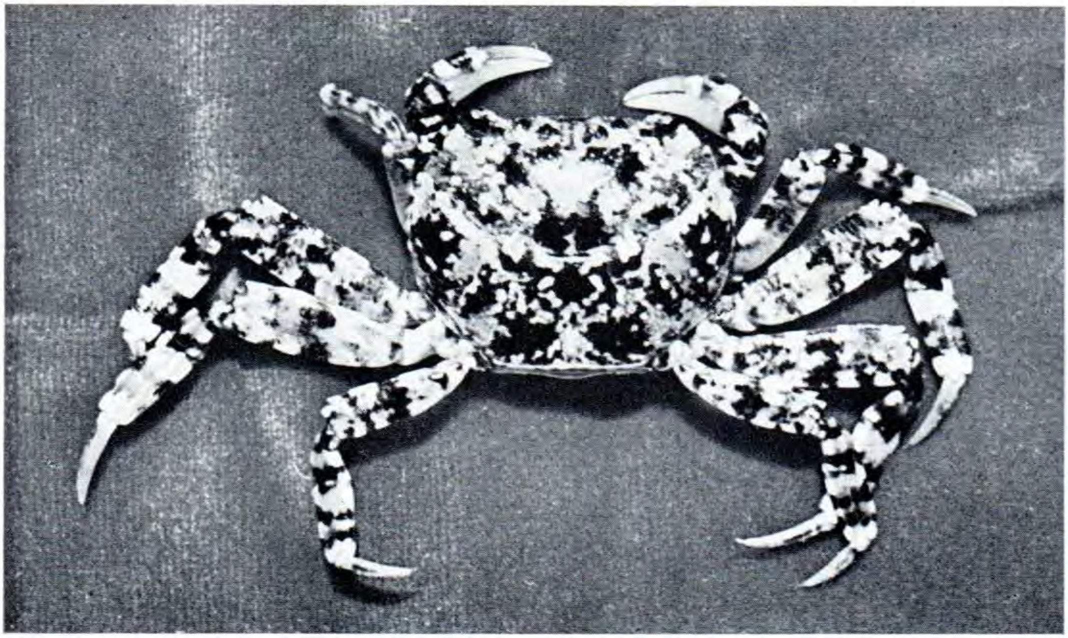
Curator of Invertebrates, Western Australian Museum

LEPTOGRAPSODES OCTODENTATUS was first described from King Island in Bass Strait by the Frenchman Milne-Edwards in 1837. Since then, this rather secretive crab has been found in Tasmania, Victoria, South Australia and Western Australia. In Western Australia it occurs as far north as the Abrolhos Islands (see map).

It can be easily recognized by its purple and yellow mottled carapace, the large pincers of the male and the presence of four pairs of low teeth on the edge of the carapace behind the eyes. These teeth prompted Milne-Edwards to give it the specific name *octodentatus* (eight teeth)—see photo on the next page.

Mr. Hale, in his book on South Australian Crustacea, calls it (under the scientific name *Brachynotus octodentatus*) the Burrowing Shore Crab—an apt name, and one that is used in this article—but although the crab burrows, it does not always live on the sea shore.

The first encounter with this interesting crab was at the bottom of a burrow, 2 ft. long, at a barred estuary near Hopetoun, W.A. There in the burrow we found a large purple and yellow male crab snapping his slender cream pincers at us. Near Denmark, W.A., on the other hand, we found them scuttling amongst the granite rocks like their near relatives and neighbours, the blue or yellow Rock Crab *Leptograpsus variegatus*; but unlike the Rock Crab they scrambled away into a nearby freshwater stream (see photo on page 74). Mr. Hale reports them in brackish wells on Flinders Island, Bass Strait, and members of the Western Australian University staff found them in freshwater soaks on Wallabi Island of the Abrolhos Group. Perhaps the most unusual habitats are the edges of the very salt lakes at Rottnest Island, off Fremantle, and at Middle Island in the Recherche Archipelago, W.A. There the crabs dig shallow burrows beneath tussocks, logs or stones; these are actually only a matter of 3 ft. to 6 ft. away from this highly saline water, yet on each occasion we have always found fresh or brackish water in close proximity to the burrow.



A mature female Burrowing Shore Crab collected at Robe, South Australia, by Dr. J. W. Shields, who took this photo of it.

In all these situations the crabs live in water of a much lower salinity than sea-water, and we have found that they can survive for long periods in ordinary tap water. The burrow positions are very carefully located in seepage areas and always at a higher level than the "high tide" level of the sea or salt lake. Nevertheless, these crabs are never found very far away from the sea, rarely further than about 200 yards from it.

Feeding

Burrowing Shore Crabs normally scavenge at night, picking up rotting vegetation and animal debris with their slender claws. In the morning, feeding paths are easily seen leading away from the burrows and these fresh "fingerprints" indicate to the daytime collector that the crab is present in its burrow.

Sex Differences And Sexual Maturity

The Burrowing Shore Crab reaches sexual maturity at a carapace breadth of about 1 in., and large adults may reach a size of about 3 in. across the back. The adult males develop much larger claws than the females; the fingers become curved and irregularly toothed, whereas the females (and the juveniles) have straight, regularly toothed fingers. Other features, such as the dentition of the wrist and the depth of a pair of pits on the carapace, also vary with age. These changes in morphology with age in the two sexes have been the cause of some confusion in the naming of this species and, in past years, three separate scientific names have been given to greatly dissimilar sexual or growth stages of this single species.

The Name Of The Species

The full scientific name of this southern Australian shore crab is *Leptograpsodes octodentatus* (Milne-Edwards), 1837. Hess in 1865 described the same species as *Grapsus inornatus* from Sydney, but Mr. Frank McNeill, formerly Curator of Crustacea at the Australian Museum, informed me that this locality is probably incorrect as the crab has not since been collected from N.S.W. Montgomery in 1942 gave a new name, *webhaysi,* to specimens from the

Abrolhos, believing that they were morphologically distinct from the eastern *octodentatus*.

Through the courtesy of the Australian and South Australian Museums, specimens from the eastern States have been compared with the Western Australian Museum series, which includes some from the Abrolhos (the type locality of Montgomery's *webhaysi*). There is no doubt as to the specific unity of these separately described "species".

Readers who use Hale's book for the identification of the shore crabs may wonder why I have used the generic name *Leptograpsodes* instead of the name *Brachynotus*. The reason is this: *Brachynotus* is a generic name of which the type species (*B. sexdentatus*) clearly belong to the subfamily Varuninae, but Montgomery has shown (1931) that the species *octodentatus* actually belongs to the sub-family Grapsinae and it cannot therefore be a member of *Brachynotus*, a genus of varunine crabs. Montgomery proposed the generic name *Leptograpsodes* for it, and his conclusion is followed here.

Reproduction

The Burrowing Shore Crab spawns in the summer months from December through to February. Females with eggs carried beneath the tail are common during these

Known localities of the Burrowing Shore Crab of southern Australia.

Map by Miss R. Hunt.

A typical habitat of the Burrowing Shore Crab at Green Pools, near Denmark, Western Australia. Here the crabs live in burrows beneath tussock rushes beside a freshwater stream flowing into the sea.

Photo.—B. R. Wilson.

times. Unfortunately we know no more, and we can only speculate on the rest of the cycle.

Do the young of the Burrowing Shore Crab hatch in the sea as tiny free-swimming larvae (like most crabs do) or do they pass their early life in the low-salinity water in the burrow of the adult?

If the larvae do require salt water then the adults must move into the sea which is close at hand. The well documented forest crabs of Christmas Island make such migratory journeys, but adults of the Burrowing Shore Crab have never been observed immersed in the sea. Another difficulty facing the larvae, if they do develop in the sea, is finding their way back to these rather specialized localities suitable for adult life along the generally arid western and southern coasts.

Captive Animals

Further investigations of the Australian Burrowing Shore Crab are required to solve some of these questions. Their survival in such a wide variety of environments makes them a very suitable animal for study in the laboratory, where their behaviour, growth and response to waters of varying salinity could be readily studied. More difficult, but perhaps more interesting, is the study of reproduction and larval development in this unusual Australian crab.

BOOK REVIEW

SEA SHELLS OF THE WORLD, by R. Tucker Abbott, a Golden Nature Guide, under the editorship of Herbert S. Zim; Golden Press, New York, 1962; pp. 1-160, with numerous coloured illustrations.

The publication of this compact guide to the better-known species of sea shells is a milestone in the literature of popular malacology; it is the first such book dealing with molluscs from a world-wide point of view, written by a professional worker and, therefore, with sound classification and an up-to-date nomenclature. There are 562 species illustrated, and they include all the shells which collectors are most likely to have in a general world-wide collection. The illustrations are good, with clear-cut outlines and reasonably accurate colours; there is scarcely any descriptive text, but this is not necessary when the figures are so clear. Dimensions and geographic ranges are given, together with information on the families of molluscs and their habits. There are one or two minor errors of classification, such as the inclusion of *Gyrineum* and *Biplex* in the Bursidae (they are in fact Cymatiids), and some well-known Australian shells will be found allotted to genera different to those used by local specialists; this is a result of the author's approach, which tends to be conservative and so to ignore the smaller subdivisions in favour of broad generic groupings. The scale on page 160 is designed for the larger De Luxe Library edition, and in the small pocket edition comes out about three-quarters natural size. But these minor criticisms should not detract from this excellent production, which will be a boon to beginner shell collectors throughout the world.—*D. F. McM.*

Scientists studying the Wandering Albatross on Macquarie Island.

Photo.—Author.

THE WANDERING ALBATROSS

A Brief Review of Studies in Progress

By M. D. MURRAY

ALBATROSSES are the largest of oceanic birds, and of the 13 known species nine are found in the southern regions of the Atlantic, Indian and Pacific Oceans. The colours of their plumage are black, grey and white and they may be divided into three groups: the Sooty Albatrosses, which are dark all over, the Great Albatrosses, which have pink bills and are white on the back and tail, and the Mollymawks, which have dark or yellow bills and a black marking on the upper surface of the wings that is continuous across the back. As albatrosses fly mainly by gliding with their wings outstretched the pattern on the ventral surface of the wings is easily seen, and this is particularly useful for identifying the various species of Mollymawks. Excellent keys for the identification of the various species of albatrosses to be found around Australia and New Zealand have been prepared by Mr. J. Moreland, of the Dominion Museum, Wellington, New Zealand.

The largest of all the albatrosses is the Wandering Albatross (*Diomedea exulans*), which has a wing span of 11-12 ft. from tip to tip and weighs 16-25 lb. It is the commonest of the Great Albatrosses and is the large white albatross which may be seen following ships in the southern Atlantic, Indian and Pacific Oceans. There it breeds on the isolated islands in the Subantarctic where, in a nest made of vegetation and standing about 12 in. high, it lays a single large white egg. The egg is laid between November and February, and female and male birds take turns to sit over it for its 60-70 day incubation. The chick, which is white and downy initially, feeds in a characteristic manner. It places its opened bill between and across the opened bill of the parent bird which then regurgitates a partially digested meal.

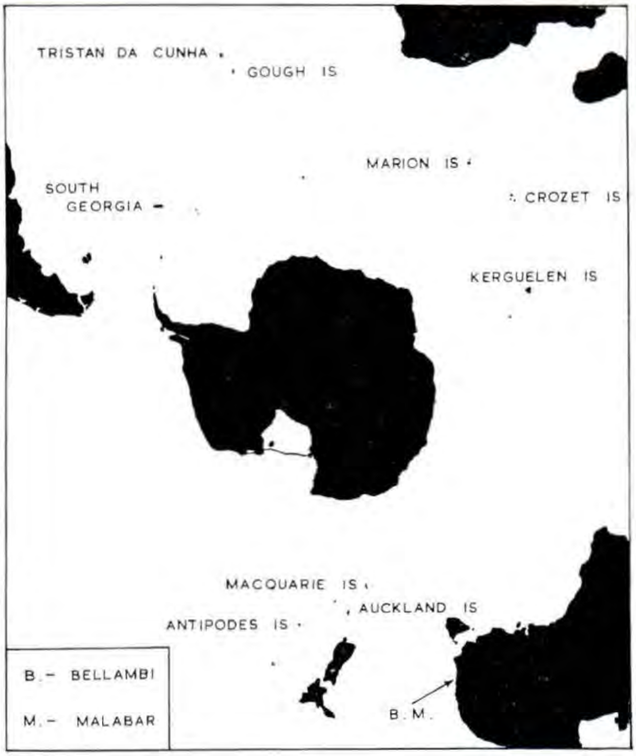
It takes about nine months for the chick to become fully grown, and whether they are or are not fed throughout the winter has been a source of controversy for many years. Some have maintained that the chicks are abandoned by the parents for the winter. To postulate this infers that the albatross chick can grow and keep warm during a Subantarctic winter without any additional source of energy other than its own fat. It would be a remarkable bird indeed to accomplish this physiological feat. The truth is that the parents feed the chick throughout the winter. This was observed by Harrison-Matthews in 1925-6, yet it has required the further observations of K. Keith, when with the Australian National Antarctic Research Expedition on Macquarie Island in 1956, to finally settle the question. A full year is required for the parent birds to build a nest, incubate and hatch the egg and feed the chick until it is capable of fending for itself. Consequently, the Wandering Albatross breeds only every second year.

The life of an immature albatross after leaving the island of its birth is largely unknown. Much has been suspected, but proof has been absent. When the immature bird first flies its plumage is brown all over but for its white face and underwing, yet the plumage of breeding birds is predominantly white. Albatrosses with varying amounts of brown and black mottling and white are seen frequently, and clearly these are birds of different ages.

But what changes take place in the plumage colouration with each successive moult, what is the relationship between these changes and the age of the bird, and where do the immature birds go? Some information has come during the last four years from a locality which may surprise many—Bellambi, New South Wales.

Albatross Gatherings

For many years one of the sights for bird-watchers has been the winter gathering of Wandering Albatrosses off the coast at Malabar, near Sydney, where as many as 600 birds have been seen sitting on the water. Another gathering occurs 50 miles south of Sydney, at Bellambi, where two amateur ornithologists have developed techniques for catching albatrosses. Since 1956 a total of 1,120 Wandering Albatroses have been captured and banded at



This map of the southern oceans surrounding Antarctica shows the islands on which the Wandering Albatross breeds. Birds banded at Bellambi and Malabar, New South Wales, have been recaptured on South Georgia and Marion Island.

Map by the author.

Bellambi by J. D. Gibson and A. R. Sefton and at Malabar by M. D. Murray, S. G. Lane and C. Campion. The first result from these efforts could not have been more gratifying. One bird which was banded at Bellambi on 23rd August, 1958, was reported to have been present on Bird Island, South Georgia, from 29th December, 1958, to 6th March, 1959. It so happened that W. L. N. Tickell, a British ornithologist, then with the Falkland Island Dependencies Scientific Bureau, was visiting South Georgia that year to initiate a study of the Wandering Albatrosses which breed in large numbers on that island. Part of his programme was a large-scale banding of albatrosses, both chicks and adults. The following July one of the chicks which he had banded in November, 1958, was captured at Bellambi. To date, 12 birds banded off the coast of N.S.W. have been recaptured on South Georgia and one on Marion Island in the southern Indian Ocean, and six birds banded at South Georgia have been recaptured at Bellambi. It may not be too sweeping to suggest that the birds which can be seen from Malabar Head on any winter's day come from any of the main breeding islands in the Subantarctic.

A real surprise has been that an average of $7\frac{1}{2}$ per cent. of the birds banded off the N.S.W. coast have been recaptured in each subsequent year at Bellambi. This indicates that albatrosses return to particular geographical regions to feed. One albatross has been recaptured at Bellambi three years in succession. The recapture rate has guaranteed the success of another study. When a bird is captured, detailed notes are made of its plumage. To standardize the descriptions of different albatross-banders the plumage is compared with a standard description, such as may be seen in the illustration on this page. Should the plumage of a bird be scored Back 2 Head 2 Inner Wing 2 Tail 1 and, when recaptured, the plumage score be 4, 3, 4, 2, the length of time required for this change can be stated. As records accumulate it will be possible to determine the sequence of plumage changes and the time required for each change. Should the exact age of some of the birds be known, then the changes in plumage can be related to the age of the bird. The mass banding of chicks in South Georgia is providing these birds of known age.

Banding Problem

On Macquarie Island there are less than 30 breeding pairs of Wandering Albatrosses. However, most of the birds are banded and

Key used for describing the plumage of Wandering Albatrosses captured off the New South Wales coast. It was designed by J. D. Gibson.

the individual breeding history of many is known accurately from 1954. It appears that some pairs remain constant for many years; they return to the same part of the island to build their nest, but whether their chicks will return to Macquarie Island is not yet known. As it is believed that this albatross does not breed until it is about seven years old, it may be too soon for the return of the survivors of the small number of chicks which have been banded.

Another problem has arisen, however. The albatross is obviously a long-lived bird, so the metal of which the band placed around its leg is made has to be durable. Re-examination of the bands on birds recaptured off the N.S.W. coast showed that the metal of the earlier type of band was weakening rapidly with age. This has been remedied, and the bands used now will last as long as the life of the bird. It is probable that many of the birds banded as chicks in the past may lose their bands before they become sexually mature and prepare to breed.

To study the Wandering Albatross is to satisfy the spirit of adventure, both physically and intellectually. The pioneering phase is over; satisfactory techniques have been developed and it will be apparent that the coming years will be most interesting. Perhaps in 10 years time it may be possible to write a life history based entirely on proven fact, but only much effort and the fullest of international co-operation will obtain the data required.

BOOK REVIEW

THE EVOLUTION OF LIVING ORGANISMS. A symposium to mark the centenary of Darwin's "Origin of Species" and of the Royal Society of Victoria held in Melbourne, December, 1959. Edited by G. W. Leeper, M.Sc.; Melbourne University Press; pp. 1-455; price £6 6s. 0d.

The title of this book is perhaps misleading, for it is not a general volume on evolutionary theory, but a number of disconnected contributions, each one of which is itself a study of some facet of evolutionary biology. Nor is it a book about evolution for the beginner in the study of natural history. Such books can be obtained from any bookstore, and the person seeking a general account of the modern theory of evolution should not attempt this work.

However, this book is an important contribution to evolutionary literature, for it presents a series of scholarly essays by Australian and overseas specialists on a broad spectrum of biological problems, with special reference to the fauna and flora of the Australasian region. To any zoologist wishing to keep abreast of the latest developments and ideas in this rapidly progressing field, the study of these contributions will prove invaluable.

Of course, it is to be expected in such a symposium that the level at which the papers are written and the nature of their presentation will vary considerably. As an example, one might contrast the general historical contribution of Sir Gavin de Beer on "Darwin and Australia" with the highly specialized "Effects of Chromosomal Inversions on Size and Relative Viability in the Grasshopper *Moraba scurra*" by White and Andrew. Some of the papers will obviously be of more general interest than others; in mentioning a few, such as Baas-Becking's "On the Origin of Life", Mayr's "Accident or Design, the Paradox of Evolution" and Ride's "On the Evolution of Australian Marsupials," we do not discredit the work of others. On the contrary, many of the specialized contributions will stand as basic references for years to come. Indeed, the principal merit of this book lies in the very diversity of its authors and their viewpoints, and the Royal Society of Victoria is to be congratulated in producing this important contribution to the development of evolutionary thought.

D. F. McM. and H. G. C.

The Angling Spider (*Dicrostichus magnificus*) is remarkable for the way in which it catches its prey. Instead of making a traditional orb-web, it merely spins a few loose threads from one branch of a bush to another. These threads form a foothold for the spider, which takes up a position on one of them and lowers a small globule of very sticky substance at the end of a thin silk line. The spider holds the line, dangling the globule, and waits for a small insect, usually a moth, to come within range. It then whirls the thread round and round in an attempt to hit the insect with the globule. If it succeeds it hauls in the thread, with the insect adhering to the globule, wraps the prey in silk, kills it and feeds on its body fluids. The photo, by Howard Hughes, shows a female Angling Spider, with the top part of its egg-case.

REMARKABLE GRASSHOPPERS FROM SOUTH AUSTRALIA

Two almost wingless species of grasshoppers of unusual appearance were recently sent to the Australian Museum by Mr. B. Flounders, who collected them in the Whyalla district, South Australia. The first of these, which has been identified as *Phanerocerus testudo,* was remarkable for its resemblance to a rough-grained, reddish-brown pebble. This resemblance was heightened by the large, shield-like pronotum of the thorax, which covers the entire abdomen. According to Mr. Flounders' letter, the insect was living among broken rock which it matched so closely in size and colour that it was only visible when it moved. Only one specimen of this grasshopper was received, and Mr. Flounders states that he had not seen one before. Specimens of it in the Museum collection are also from South Australia, and the species is apparently confined to that State. The second species was found on a lichen-covered quartz outcrop. The two specimens sent are broad and squat, the larger measuring seven-eighths of an inch in length, and resemble pieces of lichen-covered rock. Grey-green wrinkles and excrescences on the thorax and abdomen are responsible for this appearance. Mr. Flounders had previously seen other similar specimens, always on lichen-covered rocks, and has suggested that they might feed on lichens. The species was found to belong to the genus *Cratilopus,* but it was not possible to determine the species from the available descriptions. Species of *Cratilopus* have been recorded from South Australia, Sydney and Lord Howe Island. The two latter localities may be erroneous, as the insects appear to be desert forms. The photo, by Howard Hughes, shows the specimen of *Phanerocerus testudo,* 1⅛ in. long, sent to the Museum by Mr. Flounders.

"LIFE THROUGH THE AGES"

"Life Through the Ages", a coloured chart showing the progress of life through geological time, is available at the Australian Museum. The chart (34 in. x 24 in.) relies on illustrations more than on wording, and is designed for hanging in schools so that it may be seen by all children, whether they are studying the biological sciences or not. It can also be used as an aid in the teaching of science, and will be of value to lay people interested in biological subjects. The chart, published by the Museum, illustrates the kinds of life that have existed from the primitive invertebrates of more than 800 million years ago to the present, and shows the geological periods and their durations. Its price is 6s. (6s. 9d. posted).

Leaves of *Rhacopteris ovata* (McCoy) and *Cardiopteris polymorpha* Göppert, preserved in a shale of Carboniferous age from New South Wales.

PLANTS OF THE PAST

By H. O. FLETCHER

A STUDY of fossil plants discloses that all living plants are the descendants of previously existing forms, of which many are now extinct. They follow the same evolutionary pattern found in the Animal Kingdom, and for almost two billion years have been ever-changing and progressive in their development throughout geological history.

The flora of the past is just as important as the fossil fauna in determining the chronological succession of sedimentary rocks and in the correlation of similar, but widely separated, strata. The general succession of plant life through the ages has been the same in all parts of the world. Particular assemblages of fossil plants and important "index-species" are known to be restricted to separate stratigraphical units and therefore, when found, indicate the age of the rock strata in which they occur. Recent investigations are proving that fossil plant spores are far more abundant in species and numbers in the rocks of all geological ages than originally supposed, and these also are invaluable in the study of stratigraphic correlation.

The oldest known fossil plants have been recorded from rocks of Proterozoic age (Pre-Cambrian), which have an undisputed age of from 1,500 to 2,000 million years. These ancient plants, representing some of the earliest life, have been recorded from many localities in Australia and include a variety of types with a world-wide distribution.

The most abundant and well-known plants from Proterozoic rocks are calcareous algae. These are preserved in the form of structures which have been classed together and named "stromatolites". Defined as "a mineral copy or cast of the external form of an algal colony", they are usually laminated, each lamina representing one growth stage in the development of the colony, while in shape they range from cylindrical, sub-hemispherical, dome-like and conical to tubular and branching colonies. In the

Proterozoic and early Palaeozoic rocks they formed reef-life masses and were widely distributed.

Stromatolites have been recorded and described from Lower Proterozoic rocks of the Paradise Creek area in north-western Queensland, and the various types have been compared with cosmopolitan genera such as *Cryptozoön*, *Greysonia*, *Archaeozoön* and *Collenia*. Stromatolites deposited by algae of the genus *Collenia* have also been described from Proterozoic rocks in Western Australia which extend for more than 200 miles between Perth and Yandamooka. Two further species of the same genus are known from two localities in the Northern Territory and, like the other species, closely resemble well-known species from rocks of the same age in North America. Many other occurrences of stromatolites have been recorded from Proterozoic rocks in various parts of Australia and these include *Girvanella*, an alga which formed ball-like colonies.

Many types of Pre-Cambrian algae continued into early Palaeozoic time, and in the Cambrian and Ordovician periods reefs were still formed by them in all parts of the world. There appears, however, to be a noticeable decline in their numbers following Proterozoic time, and it has been suggested that possibly the great evolutionary trends among the algae were already established before the close of this period. Algae which are very simple in structure and live in shallow seas, brackish lakes and freshwater pools have persisted throughout geological time to the present day. As some are limestone-making plants, they have assisted in the formation of the great limestone deposits of the past.

Fossil algae, fungi, bacteria and most other recorded plants from the very ancient rocks belong to a division of the plants known as the Thallophyta. The thallophytes are mainly aquatic forms, and also include the diatoms and the seaweeds. They are the simplest and most primitive of all plants, and, with few exceptions, there is no differentiation into stem, root and leaf. A great many are single-celled and microscopic in size, although the seaweeds have been recorded with a length of 100 ft. and with huge trunk-like stems. In fact the seaweed *Macrocystis* is reputed to exceed in length the height of the tallest trees. Diatoms occur in both fresh water and the sea, and during Tertiary time were so abundant that their minute skeletons, impregnated with silica, formed thick deposits in many parts of the world. These great deposits of what is termed diatomaceous earth are not known earlier than the Cretaceous period. The absence of any vascular tissue in the thallophytes prevented the development of any woody structure and is the reason why this division of plants did not successfully attain a terrestrial mode of life.

The First Land Plants

The oldest known land plant is a primitive form found in rocks of middle Cambrian age in Siberia. It is thought to have affinities with the Lycopodiales, a group of plants which includes the living club-mosses, *Lycopodium*, and the giant scale-trees, *Lepidodendron* and *Sigillaria*,

Typical leaves of the *Glossopteris-Gangamopteris* flora.

which came into existence in late Devonian and Carboniferous times and became extinct before the close of the Palaeozoic Era.

This meagre record from Siberia, with occasional others, is evidence that vascular plants had grown on land very early in the Palaeozoic, about 800 million years ago, and it is possible that further specimens remain undiscovered in continental shales deposited along the banks of rivers and estuaries in Cambrian time.

Land plants of Silurian age are the first in which structural features are sufficiently preserved to enable a detailed study to be made, and these remains, limited in number and variety, have been collected in various countries, including Australia. An important flora, later to become world-famous as the "Baragwanathia flora", was discovered in 1908 in rocks of Silurian age in Victoria. Further remains of this flora have since been recorded in Tasmania and at Yass in New South Wales.

The most advanced genus of the flora is *Baragwanathia*, represented by the one species *B. longifolia* Lang and Cookson. The plants of this species are branched and the stems are densely clothed with slender, needle-like, leafy shoots. Kidney-shaped sporangia (spore cases) which are only 2 mm. long are developed between the larger leaves and stem near the tip of the plant. Although certain features of *Baragwanathia* are suggestive of the Psilophytales, the simplest land plants known, it is now generally accepted as being more closely related to the "club-mosses" of the Lycopodiales.

Other plants which form part of the "Baragwanathia flora" possess psilophytalean affinities, and they include the genera *Hedeia*, *Yarravia* and *Zosterophyllum*. The fossil remains consist mainly of unbranched stems, but in most cases associated sporangia were also preserved. The remains of seaweeds are frequently found in the Silurian shales and mudstones of Victoria

A branched plant, *Baragwanathia longifolia* Lang and Cookson, from rocks of Upper Silurian age in Victoria.

and New South Wales, and specimens found at Brunswick, near Melbourne, when viewed under the microscope, show the actual cells of the plant.

There was no considerable evolutionary progress in the development of plants during the 30 million years of Silurian age, and it was not until the succeeding Devonian period that land plants increased considerably in variety and complexity. Recent investigations of plant spores in Devonian sediments have shown that the flora of the early Devonian was far more diversified and abundant than is suggested by the recorded larger fossil remains of plants.

The Devonian flora of about 400 million years ago readily falls into two very well marked divisions. An early flora (Lower and Middle Devonian) consists mainly of simple herbaceous and rush-like Psilophytales, while a later flora (Upper Devonian) is characterized by the development of more progressive and advanced plants, including seed-bearing forms and the first forest trees, some of which were at least 100 ft. high.

One of the most important of the recorded occurrences of Lower Devonian plants is the "Rhynie flora" which was discovered in lower-middle Devonian sediments near Rhynie, in Scotland. The plants representing this flora are perfectly preserved, some in the original position of growth, and the cell structures are clearly shown. They are simple forms of Psilophytales and consist mainly of slender, straight and branched stems without any true roots.

The late or Upper Devonian flora shows a marked change from the early flora of this period, and in all parts of the world some of the major groups of the more advanced plants make their appearance for the first time in geological history. The oldest known forests of this time were apparently mainly restricted to low-lying, marshy areas, but some plants growing on drier land began to develop characteristics of the more modern groups. Primitive plants, such as the Psilophytales with their practically leafless stems, had by this time become fewer in numbers.

The true ferns (Filicales) are among the common plants of the Upper Devonian, and many species, representing most of the main groups, were becoming well-established and abundant. They continued to develop throughout all the succeeding geological ages, and to-day form a large part of the world flora. The true ferns reproduce by means of spores which are cast free from the parent plant to generate and care for themselves, whereas the seed-ferns (pteridosperms), although very fern-like in appearance, differ markedly in that they are seed-bearing and more complex in their reproduction. The development of the pteridosperms in the late Devonian was an important step in the evolution of plants and, although they became extinct at the close of the Palaeozoic, they had already given rise to other groups which continued to flourish.

The trees which dominated the Upper Devonian forests were the large branching scale-trees, *Lepidodendron* and *Protolepidodendron* (Lycopodiales). Trees of *Lepidodendron* grew to heights of more than 90 ft. and, with trunks up to 6 ft. in diameter, towered above the rest of the flora. The top third of the tree was developed into a canopy by repeated forking into many branches densely clothed with long, simple, needle-like leaves which attained a considerable length. As the trees grew and shed their leaves, they left behind on the stems permanent leaf-scars which were rhombic in outline and varied in shape and mode of arrangement in the different species.

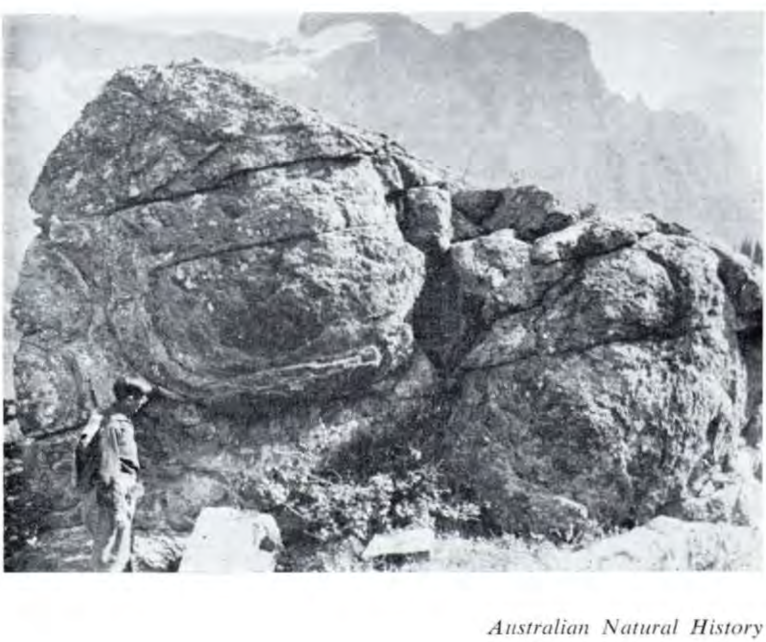
The most characteristic of the Upper Devonian plants found in Australia is *Lepidodendron australe* and this form, possibly representing several species, is known mainly from trunk and stem remains in many parts of Australia. The more primitive genus, *Protolepidodendron,* with smaller and bifurcated leaves, has been recorded from Middle Devonian rocks in Queensland and from Upper Devonian rocks at Yalwal and Eden, in New South Wales.

Another type of large forest tree which had early representatives in the Upper Devonian was *Cordaites* (Cordaitales), a family of trees which attained maximum development during Carboniferous and Permian times, continued with diminished numbers into the Mesozoic era, and became extinct soon afterwards. This group is regarded as the ancestral form of the Ginkgoales trees, which, although fairly abundant in the Mesozoic and Tertiary eras, are represented at the present day by only a single species, *Ginkgo biloba*, the Maiden-hair Tree. The Ginkgoales possessed the general habit of conifers and grew to heights of more than 75 ft. The trees of *Cordaites* also grew to similar heights, with a tall trunk and spirally-disposed spreading branches on which leaves of a simple spatulate type grew to a length of about 6 ft. They bore a superficial resemblance to the conifers, but their seeds were arranged in clusters, whereas in the true conifers they are arranged in cones. The remains of *Cordaites* have been found in beds of Upper Devonian age at a number of localities in Australia.

The late Devonian forests, as they became established in all parts of the world, formed a moist and shady environment in which the first land vertebrates lived. The forests also became the home of arachnids (spiders) and insects, which at this time were rapidly developing along a number of evolutionary lines leading towards what was to be a remarkably advanced and complex arachnid and winged-insect population in the succeeding Carboniferous and Permian forests.

There was no great spectacular change in the flora of the world as it continued into Lower Carboniferous time, and the scale-trees, *Lepidodendron*, the seed-bearing ferns and the true ferns were largely similar to those of the Upper Devonian. The early Carboniferous flora of Australia contained species of *Lepidodendron* quite distinct from *L. australe* of the Upper Devonian, together with *Ulodendron*, the stems of which are characterized by large leaf-scars, *Cyclostigma* (allied to *Protolepidodendron*) and *Stigmaria*, a genus in which what is now known to be the rhizome or underground root system of *Lepidodendron* was placed. The true ferns are represented by genera including *Clepsydropsis* and *Aneimites*, and a gymnosperm, *Pitys*, which grew to a height of nearly 50 ft.

A group of plants, including the calamarians (scouring rushes), equisetaleans (horse-tails) and Sphenophylls (creeping or climbing plants), originated during Devonian time, but did not reach their maximum development until Carboniferous and Permian times. These plants are fairly common in Australian rocks and are easily recognized by their vertically ribbed and regularly jointed stems. Later in geological history they became extinct, with the exception of the single genus *Equisetum* (horse-tail), which survived to the present day and is represented by about 24 widely distributed species.



A Pre-Cambrian reef of calcareous algae exposed in the Glacier National Park, Montana, U.S.A., showing concentric lamination.

From "Historical Geology," by Carl O. Dunbar.

The Upper Carboniferous flora is marked in most parts of the world by a great development of the true-ferns and the seed bearing fern-like plants and also a diminution of the *Lepidodendron* flora. In Australia, the most characteristic of the true-ferns was *Rhacapteris*, a genus which did not extend beyond the Lower Carboniferous in the northern hemisphere. Associated with the *Rhacopteris* flora are genera such as *Lepidodendron* and *Asterocalamites*, which suggests a Lower Carboniferous age rather than a younger one. Both the *Lepidodendron* and the *Rhacopteris* floras of Australia have very little in common with the Upper Carboniferous floras of the northern hemisphere, and it has been suggested that there is a considerable time-break between our youngest Carboniferous flora and the *Glossopteris* flora of the succeeding Permian period.

The Permian period is characterized by two very distinct floras, one restricted almost entirely to the northern hemisphere and a second flora found only in the southern hemisphere. In the north the reed-like *Calamites*, the giant scale trees (*Lepidodendron*) and other types of plants, which originated during Carboniferous time, lived on until near the close of the Permian. In the southern hemisphere there was a marked change from the previous Carboniferous flora, and plants such as *Glossopteris*, *Gangamopteris*, *Noeggerathiopis*, *Phyllotheca* and *Schizoneura* came into existence and flourished. It is from the remains of this flora that the important coal-fields of New South Wales, Queensland and Western Australia were formed.

The great abundance of plants in the *Glossopteris* flora are virtually restricted to Australia, South America, South Africa, Antarctica and peninsular India, continents which are considered by many scientists to be the surviving remnants of a great southern land known as Gondwanaland. This land was separated from the Eurasian land areas by an east-west Tethys Sea which was in existence from early Permian to Jurassic time.

The most characteristic genus of the southern flora was *Glossopteris*, which had seed-like reproductive structures, and it is usually considered, somewhat doubtfully, to be a seed-bearing (pteridosperm) plant. Approximately 26 species have been described, many of which are widely distributed, and it is the most dominant of all Permian plants, some sediments being made up almost entirely of the matted remains of the leaves. Specimens of *Glossopteris indica* were collected from rocks of Permian age near the Beardmore Glacier in Antarctica by Captain Scott's party during their ill-fated journey to the South Pole in 1912. These specimens, with other fossil plants, were found with the bodies of the polar party at their final camp.

It is rarely that the leaves of *Glossopteris* are found attached to the stems on which they grew, but it is now usually accepted that they grew in circlets and were originally connected with stems described in the past as *Vertebraria*, a common form in the *Glossopteris* flora. The leaves of *Glossopteris* are spatulate in shape and possess a strong mid-vein, which gives off a network of secondary veins. Leaves of the closely related genus, *Gangamopteris*, differ in that a mid-vein is absent, and, although just as widely distributed as *Glossopteris*, they are more characteristic of the Lower and Middle Permian rocks.

The Equisetales (horse-tails) are well represented in the *Glossopteris* flora by important genera such as *Schizoneura* and *Phyllotheca*, the last-named occurring abundantly in the form of small leaf-whorls somewhat resembling, superficially, the petals of flowering plants. *Schizoneura* is a similar type of plant to *Calamites*, with a jointed stem, but differs in having larger and broader leaves. The genus *Sphenophyllum*, which ranged from the Upper Devonian to early Triassic time, is a climbing type with slender-jointed stems and circlets of wedge-shaped leaves, and has been recorded from rocks of Lower Permian age in Queensland. *Annularia* and *Sphenophyllum* had already appeared in the Carboniferous of the northern hemisphere and are two of the few plants occurring in both the northern and *Glossopteris* floras.

The Cordaitales, distant relations of our modern pines and firs, are represented by the petrified trunks of *Dadoxylon* and leaves known as *Noeggerathiopsis*, both of which are related to the northern genus *Cordaites*. The conifers (Coniferales) first came into existence during Permian time, probably derived from the Cordaitales, and in Australia are represented by genera such as *Walkomiella*. Beautifully preserved examples have been collected from rocks of Upper Permian age at Ulan, New South Wales, while a second species, *W. crassum*, is known from Jurassic and Lower Cretaceous rocks in Queensland.

The Mesozoic Era

The Mesozoic Era, consisting of the Triassic, Jurassic and Cretaceous periods, had a time duration of about 160 million years. In most parts of the world, including Australia, the change from Palaeozoic time into the Mesozoic Era was a quiet one with no marked difference in sedimentation. There was, however, a distinct change in the flora, and, apart from an overlapping of certain plant genera, the flora became dominated by new and characteristic types of plants.

The flora of the Triassic and Jurassic was generally a uniform one, and in most parts of the world was characterized by an increase in the Coniferales, followed by a dominance of Cycadophytes and Ginkgoales. The Jurassic period is frequently referred to as the Age of Cycads, and the few sparsely scattered living genera of the group are the direct descendants of forms which overspread the world in early and middle Mesozoic times. In the Cretaceous period, about 100 million years ago, there was a spectacular rise of the flowering plants (Angiosperms), and very quickly they overshadowed the existing flora in all the continents of the world.

Thinnfeldia

During Triassic time in Australia the fern-like plants (pteridosperms) were well represented by a number of genera, including *Dicroidium* (originally known as *Thinnfeldia*), and species of this genus are found in abundance in Triassic and Jurassic rocks of Queensland and New South Wales. The typical genus *Thinnfeldia* is now known to be restricted to the northern hemisphere, whereas *Dicroidium* is known only from the southern hemisphere.

The true ferns (Filicales) also form one of the principal elements of the Mesozoic flora, and include genera such as *Coniopteris*, *Cladophlebis* and *Dictyophyllum*. *Osmundites*, with fern-stems similar to the living Royal Fern, is fairly common in Jurassic rocks of Australia. Other ferns, such as *Gleichenites*, *Hausmannia* and *Ruffordia*, attained their maximum development in the early Cretaceous period. The Coniferales were the main trees in the early Mesozoic forests, and some logs of conifer trees found in the Petrified Forest of Arizona are 200 ft. long and 10 ft. in diameter at the base. In Australia the conifers are represented by fossil stems, leaves and cone-

A frond of *Dicroidium odontopteroides* (Morris).

seeds of various genera. The cycads and related plants include a number of genera which are mainly restricted to rocks of Jurassic and Cretaceous age, while the Ginkgoales are represented by the genera *Ginkgoites* and *Baiera*.

In early Cretaceous time the older Mesozoic flora began to die out and became replaced by the Angiosperms (flowering plants). This group increased so rapidly that by the end of the Cretaceous it had overspread the world. The oldest of the flowering plants which appeared in early Cretaceous times include deciduous trees, such as the magnolia, fig and poplar. By middle Cretaceous time the forests were essentially composed of modern plants and included beeches, birches, maples, oaks, and planes, while shrubs like the laurel, ivy and holly were also in existence.

The Angiosperms are divided into two classes, the Monocotyledons, in which the plant begins life with a single leaflet, and the Dicotyledons, in which the plant begins life with two seedling leaves. The former, with undivided seeds, have leaves which are parallel-veined, whereas in the latter class, with the seeds divided into two equal parts, the leaves are usually netted-veined.

Throughout the Tertiary Era there was a great increase and spread of the Angiosperms, and to-day approximately 125,000 living species have been described. Early in Tertiary time the ferns and conifers were fairly abundant, but the cycads had diminished considerably in number. Tertiary rocks in Australia have yielded an abundant fossil flora consisting largely of isolated leaves, many of which bear a very close resemblance to the leaves of plants living to-day.

[*Except where stated otherwise, photos in this article are by Howard Hughes.*]

"Mermaid's Pennies," first discovered in New South Wales in 1959, have now been found to be the foram *Discobotellina biperforata.*

Photo.—Howard Hughes.

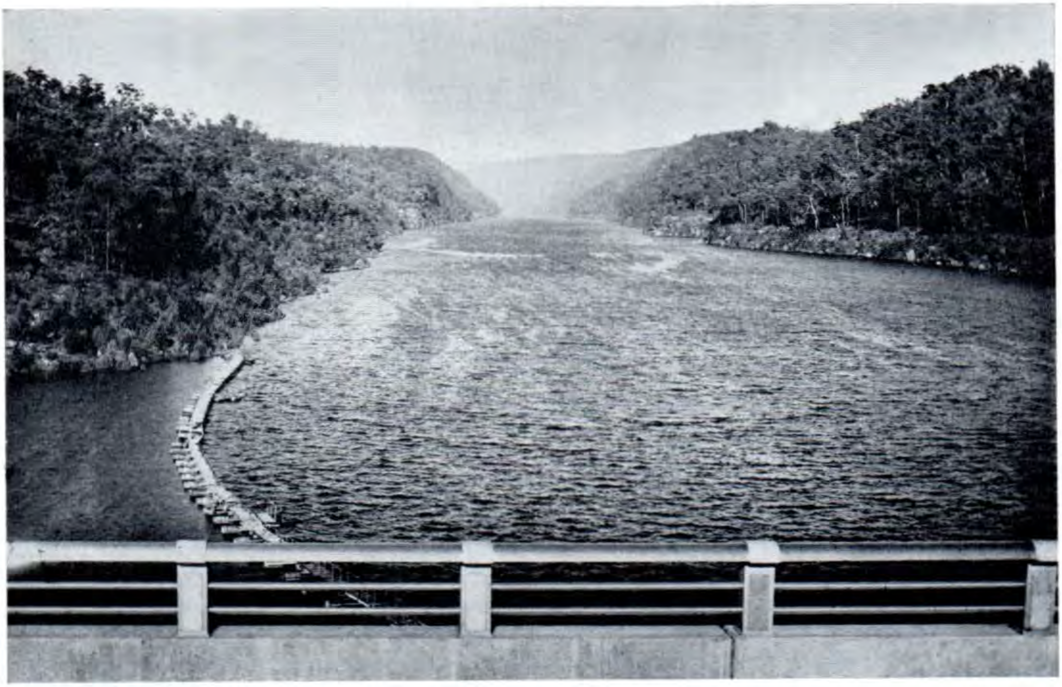
Late in August, 1961, it was announced that Professor W. Stephenson, of the Zoology Department of Queensland University, had dredged up some interesting objects in Moreton Bay, Queensland, which he called "mermaid's pennies".

These "mermaid's pennies" are flat, brown discs composed of sand grains cemented together in a regular succession of rings. They vary in diameter from about 1 in. to 1½ in. The disc is about one-sixteenth of an inch thick at its outer rim and is thinner towards its centre; in fact, there is often a slit or a pair of irregularly-shaped holes towards the centre.

The existence of these "pennies" in New South Wales had been known in the Australian Museum since 1959, when Mrs. Jean Ball sent in some half-dozen "sea pennies" from Wooli, on the north coast of New South Wales, and asked for information about them. At the time, the "pennies" were tested chemically and microscopically and were found to contain no limy material cementing the sand grains together. When heated, however, they charred readily, showing that carbon was present, and there was a smell reminiscent of singed hair or horn. This pointed to a possible animal origin. Microscopically there was no trace of rings of concentric chambers, as one finds in forams like *Marginopora,* which is common on the beaches of coral cays along the Great Barrier Reef.

The "pennies" are now known to be giant forams, of a peculiar kind, and are called *Discobotellina biperforata.* They were first described in 1958 in a Report of the British Museum of Natural History on the Great Barrier Reef Expedition of 1928-9. They differed in structure from all previously known foraminfera to such an extent that a new genus had to be created for them.

Professor Stephenson hopes, by keeping freshly dredged "mermaid's pennies" in aquaria, to find out something of their life history, physiology, rate of growth and other living processes. The results of this research will be awaited with interest.



Warragamba Dam, from the wall.
Photo.—Metropolitan Water Board.

The Biology of Warragamba Dam (Lake Burragorang)

By V. H. JOLLY

Biologist, Metropolitan Water Board, Sydney

PRIMITIVE man camped in the vicinity of streams, lakes and water-holes, where he could quench his thirst and hunt the game which also came to seek water. As he became more civilized he learnt to conserve water by building tanks and damming streams. Cities grew up on sites chosen for varying reasons, such as being suitable for fortification, having easy access to transport routes, or being near productive soil or rich mineral deposits. Probably no thought was given to supplies of potable water other than that necessary for immediate needs. Little could the original inhabitants of Sydney, drawing their modest requirements from the Tank Stream, have foreseen a city demanding some 300 million gallons of water a day.

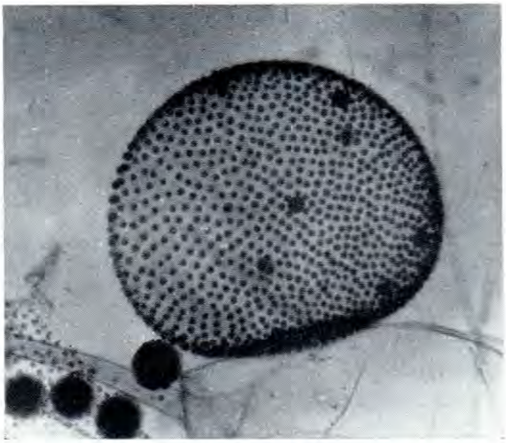
With the terrific increase in populations, engineering ingenuity has been called upon to satisfy demands for water by building huge dams, holding reservoirs of water in natural basins, and constructing tunnels, canals and pipe-lines to carry this water to distant cities. Six reservoirs now supply the water for Sydney, the largest of which is Lake Burragorang, containing nearly half a billion gallons of water, held in rocky valleys by the recently-built Warragamba Dam. Such bodies of water, despite their artificial origin, develop the flora and fauna characteristic of lakes.

Animals, whether they are terrestrial, marine or freshwater, are dependent on plants, and plants derive benefit from their association with animals. Communities therefore develop composed of three main groups of organisms, recognised as *producers, consumers* and *decomposers*. These are linked together in what is termed a food-chain.

In lakes, where an almost closed community exists, the interdependence of plants and animals is clearly defined. The *producers* are the algae living in the open waters and the rooted plants growing around the shores. These are grazed by animals in the water, mostly microscopic in size, but including, also, some insect larvae, molluscs and fish. The plant-eating animals are the *primary consumers*, and they are preyed upon by the *secondary consumers*, which include carnivorous insect larvae, fish, birds and man. The *decomposers* are worms and insect larvae which break down detritus by passing it through their alimentary tract in order to obtain food, and the bacteria and fungi, which convert organic matter into salts that are utilised by plants. The food-chain is thus completed and the only loss to the community is that of insects which may fly away and fish removed by man and birds.

Three zones, littoral, limnetic and abyssal, provide different habitats in a lake. Some organisms are confined to these by environmental factors, but others are able to pass through them at will in search of their requirements.

Lakes vary tremendously in the number of animals they contain, and may be classed as rich or poor, according to the crops of plankton or of fish they produce. While a productive lake is desirable from a fisherman's point of view, it is undesirable for city water supplies. This is not because the life in the water is actually harmful to man, since natural waters do not contain pathogens, but because some organisms when abundant create unpleasant tastes and odours and may cause engineering problems by blocking filters and meters. Therefore, while to an engineer the paramount objective is to produce as much water as cheaply as possible, the chemical and biological aspects cannot be neglected.



Volvox, one of the "Green Algae," rolls through the water like a ball. It is composed of hundreds of small cells joined together in a net. Eighty times natural size.

Photo.—M. A. Chapman.

Lake Burragorang has only reached its full area (29 sq. miles) and top level (max. depth, 343 ft.) within the last few months, but the stored water has been gradually building up for over three years and already contains most of the groups of plants and animals common to reservoirs and lakes the world over.

Life In The Limnetic Zone

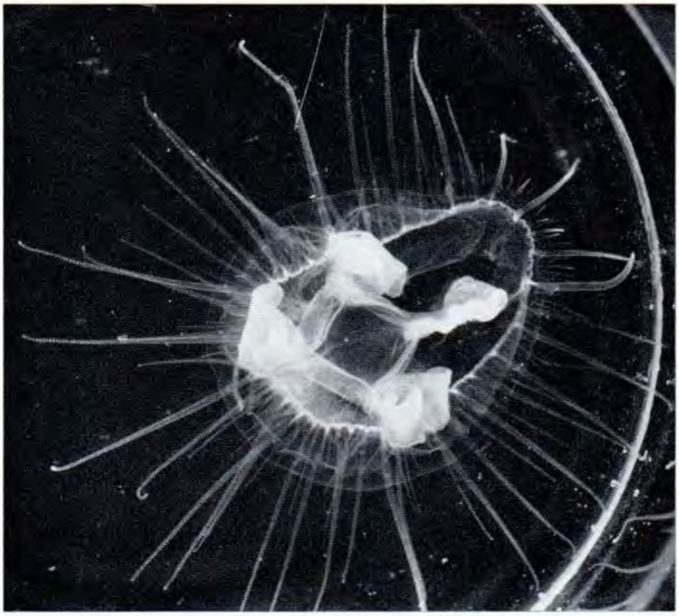
The limnetic zone is the home of the "drifters", which are at the mercy of the wind and currents, although many are capable of some movement. Plankton is a general term covering this form of life, and it comprises phytoplankton (plants) and zooplankton (animals).

Phytoplankton.—The *phytoplankton* has has been found to contain some 35 genera belonging to the five classes of algae—Chlorophyceae, Chrysophyceae, Bacillariophyceae, Myxophyceae and Dinophyceae. The number of species is unknown, but may exceed 100. Diatoms (Bacillariophyceae) are usually varied and numerous in lakes, but in Burragorang they are rare except in some isolated headwaters. Those most commonly found belong to the genus Melosira, which is a colonial diatom with cells joined end to end. The Chlorophyceae, often referred to as "Green Algae", are well represented by desmids such as *Staurastrum*, *Cosmarium, Closterium* and *Micrasterias*. These are easily recognized by their characteristic shapes, resembling stars, butterflies, bananas, etc., and by the fact that each cell is composed of two like halves joined by a little bridge. *Volvox*, another "Green Alga", is common at certain seasons of the year and when seen alive is most attractive. It is composed of hundreds of small cells, joined together in a net forming a round ball, which rolls through the water propelled by its miniature oars. The Dinoflagellates have a sculptured appearance, greenish-brown colour and transversely inserted flagellae. Two well-known genera are common—the barrel-shaped *Peridinium* and the three-pronged *Ceratium*. *Dinobryon*, a colonial member of the Chrysophyceae, golden brown in colour, is composed of a number of flask-shaped cells. It makes spectacular appearances, dominates the plankton for a week or two and then may completely disappear. These seasonal fluctuations of members of the plankton are quite common and help to make plankton studies full of excitement, since it is like watching the changing seasons in a garden.

Zooplankton.—Although the *zooplankton* is rich it is not as varied as the phytoplankton. The only protozoa commonly found is a ciliate which provides an unusual example of symbiosis. Dozens of small green plants known as *zoochlorellae* live within the body cavity of this little pear-shaped animal, utilising the by-products it gives off in respiration. They provide, in return, oxygen which they give off during the process of photosynthesis. Unusual visitors, appearing on two occasions, have been the medusae of the polyp *Craspedacusta sowerbyi*. These minute jelly-fish, about the size of a sixpence, appear to dance in the water as they undulate their silvery white umbrellas.

The Entomostraca are the most common components of the zooplankton. They are represented by the copepods, which resemble minute shrimps, and the cladocera, commonly but unjustly referred to as water fleas, because they move through the water with jumpy movements. Four species of copepods are present: two species, *Calamoecia ampulla* and *Boeckella fluvialis*, are Calanoids, and *Mesocyclops leuckarti* and *Eucyclops viridis* belong to the Cyclopoids. Calanoids are recognized by having one egg-sac and tail spines of equal length, while the Cyclopoids have two egg-sacs and tail spines which are unequal in length.

Four species of cladocera occur spasmodically in great numbers—*Bosmina meriodionalis, Ceriodaphnia quadrangula,*



A medusa (jelly-fish) of the polyp *Craspedacusta sowerbyi*. These jelly-fish, about the size of a sixpence, have been seen only twice in Warragamba Dam.

Photo.—Metropolitan Water Board.

Daphnia carinata and *Daphnia galeata*. The occurrence of *D. carinata* is interesting, since it is a pond rather than a lake type, and occurs only when the water is rich and turbid. It is also found in all kinds of ponds and puddles and in deep, still holes in rivers like the Murray, where it is so variable in size and shape that it is often hard to recognize as the same species. The cosmopolitan species, *D. galeata,* develops in Lake Burragorang such an extravagant elongation of the tail spine and head that

A cladocera, *Daphnia galeata*, notable for the elongation of its tail and head spines. Forty times natural size.

Photo.—M. A. Chapman.

it is surprising to find it so closely related to the northern hemisphere species.

A number of species of rotifers appear at various times, the most common being *Keratella cochlearis* and *Asplanchna priodonta*. Rotifers are sometimes referred to as the wheel animacules because of a circle of cilia, the movement of which creates currents that sweep food into their mouths, giving them the appearance of a rotary mower.

The Entomostraca spend only part of their time in the limnetic zone, for they have negative reaction to strong light, and move deep down in the water during daylight but return to the surface waters at night to graze on the phytoplankton which provides their food. The interesting *Chaoborus larvae* are frequently collected during deep plankton tows. These young midges have two gas-filled, kidney-shaped chambers, situated fore and aft, which act as hydrostatic organs enabling the animal to alter its position in the water.

The Littoral Zone

In Burragorang there is as yet almost no development of littoral life, because changing water levels have prevented the establishment of aquatic plants, and, in addition, the margins are for the greater part steep rock walls. Shore collections have so far yielded little but shrimps and a few insect larvae belonging to the Trichoptera (caddis flies) which live in cases made by themselves from sand grains, bark, or grass stems.

The Abyssal Zone

The dark waters of the abyssal contain little life, for it is a non-productive zone. Insect imagos such as *Chironomids* pass through on their way to the surface and fish may penetrate to feed. Lake Burragorang, although it has heavy deposits of silt in some places, is too young for a true bottom fauna to have developed, and the only animals collected have been some worms belonging to the Family Naididae and the larvae of two Chironomid species. These midges are able to survive in conditions low in oxygen because of the haemoglobin present in their blood, the red colour of which has caused the name of "blood worms" to be applied to them.

Dispersal

It may be wondered how in such a short time a newly-formed lake can become populated with such a wide range of organisms, most of which do not live in the rivers which flow into it. This is largely due to the capacity of freshwater organisms to produce, in response to a change in the environment, such as the drying-up of the water, various types of "spores", cysts and resting eggs, which contain food reserves and are protected by a coat so resistant that they can survive for years. These are so light that they are carried as dust by the wind or borne on the feet of birds and animals. As soon as they become wet they

A dinoflagellate, *Peridinium*, (centre), with a rotifer, *Keratella*, above and below it.

Photo.—A. Crispe.

germinate or hatch, and, if they find themselves in a suitable situation, rapidly reproduce; lakes and ponds can therefore be quickly populated.

Such easy means of dispersal are largely confined to planktonic forms. However, insects can move from place to place in their adult phase and deposit their eggs in or near the water, and molluscs may be moved by streams or birds' feet. Fishes can come by way of influent or effluent streams, and there are cases on record of small fishes caught in a waterspout being returned in downpours of rain. When a reservoir is formed by damming a stream some fishes may be trapped above the dam wall. This creates a problem for those fishes which normally return to the sea, either to feed or breed. Lake Burragorang contains many eels which will be forced to die there without spawning unless they slip down the spillway during a flood. Innumerable tiny eels, known as elvers, have been seen trying to ascend trickles of water at the dam wall, but whether any actually get over is doubtful, and so the lake may never be re-populated.

It is recognized that it takes up to eight years for a new reservoir to reach equilibrium, and therefore some of the interesting plants and animals now present in Lake Burragorang may disappear as the environment changes. On the other hand, however, exciting new species may still appear.

Colonies of hydroids, *Hydractinia epiconcha*, living on snails, *Parcanassa jonasi*. Upper and lower surfaces of the snails' shells are shown. (Magnified five times).

Photo.—Peter Wolff and Isobel Bennett.

Hydroids on Marine Snails

On estuarine flats with beds of Eel-grass (*Zostera*) in places such as Sydney Harbour, Tuggerah Lakes, Pittwater, and Botany and Gunnamatta Bays, there is a small carnivorous snail, *Parcanassa jonasi*, about 1 cm. in length, which can be collected in large numbers. It is usually found either on the fronds of the *Zostera* or gliding over the muddy sand of the shallow pools left on the flats by the receding tide.

In Middle Harbour, Sydney, where hundreds of these shells were collected within the space of half an hour, it was recently found that at least 90 per cent. of the snails collected were covered by what appeared to the naked eye as a fine, white, fuzzy growth of some sort. Under the microscope this was revealed as a colony of tiny, delicate hydroids. Specimens were sent to the British Museum to check the identification of the species, which appears to be *Hydractinia epiconcha*.

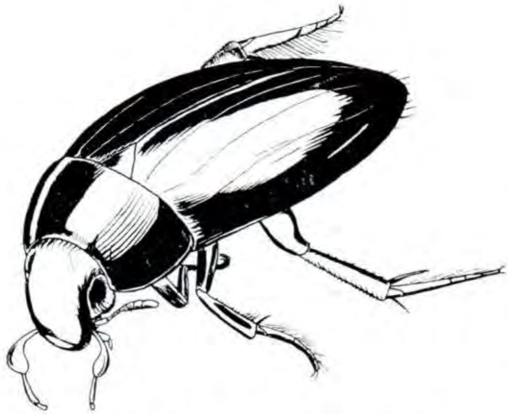
There are several rather extraordinary things about this discovery. In the first place it is strange, considering the numbers present in Middle Harbour, that this genus does not appear to have ever been recorded from Australian waters before. To date, the only member of the family described from Australia lives on the shell of a snail from Barrier Reef waters—incidentally, a carnivorous snail belonging to the same family as *Parcanassa*.

But the exciting part is that *Hydractinia epiconcha* is a well-known Japanese species which lives on shells occupied by hermit crabs. It is a characteristic of species of the hydroid family *Hydractiniidae* that they are very often found as associates of other animals, and, while some species may be found free-living in the sea, many are found only on one particular shell, fish or other animal. None of these is in any way parasitic, but the degree of symbiosis or commensalism apparently varies with different host animals. For example, it is difficult to see just how the hydroid would benefit the snail *Parcanassa*, but, in the case of the hermit crabs in Japan, it is definitely stated that the hydroid colony overgrows the shell to such an extent that the hermit crab's living space is constantly enlarged, with the result that it does not have to keep seeking bigger shells as it grows.

Another interesting fact is that on *Zostera* beds of the estuaries of Cape Province and Natal, South Africa, an identical association is found—that of a Nassariid snail with colonies of another species of *Hydractinia*.

When the Middle Harbour snails were fed tiny pieces of chopped-up worms from the same mud-flats, it was seen that the hydroids immediately turned, with the tentacles rapidly expanding, in the direction of a floating particle of worm, and within seconds this was engulfed by one of them.

Snails were collected in January, February, March and April of 1962, and during all this period the hydroid colonies bore both feeding and reproductive zooids.—*ISOBEL BENNETT, Department of Zoology, University of Sydney.*



A hydrophilid water beetle, *Hydrous latipalpus*, common in eastern Australia; length, 1½ in.

WATER BEETLES

By DAVID K. McALPINE

BECAUSE of the extraordinary number of beetle species and their varied habits, it is not surprising that numerous kinds live in water for the greater part of their lives. Most of these live in freshwater lakes, streams and ponds, a very few living in brackish or salt water. At least nine families of beetles consist largely of aquatic species, but of these only three are familiar to the general observer. These are the families Dytiscidae (typical water beetles), Gyrinidae (whirligig beetles) and Hydrophilidae (a variety of different kinds, many not aquatic). These are all more or less smooth, streamlined, oval beetles. The gyrinids are easily distinguished by their long fore-legs which contrast with the short, flattened, paddle-like middle and hind pairs of legs. The dytiscids and hydrophilids have the hind legs longer than the other two pairs, but while the latter have very short, clubbed antennae, no longer than the palpi (the jointed mouth appendages), the former have longer, thread-like antennae.

Life Cycle

The life cycle of the beetle *Dytiscus* may be taken as that of a typical water beetle. The eggs are laid in slits in water plants. The young larvae which hatch from them are active, elongate creatures with well-developed legs and long mandibles. As there are no gills, the larva must swim to the surface periodically to renew its air supply. This it does by breaking the surface film with the tip of the abdomen, on which are situated a pair of respiratory openings, the spiracles. These lead to the complex system of air-tubes (tracheae) which carry the air to all parts of the body. The larvae feed on small water animals, including insects, snails, worms and tadpoles. The prey is grabbed with the mandibles, each of which has a hollow channel connecting with the mouth. Through this a digestive fluid, containing enzymes, is pumped into the body of the victim. This breaks down and liquefies the internal parts of the animal, which are then sucked back through the mandibular channels. When the larva has grown to full size it leaves the water and makes a hollow chamber in the bank where it enters the pupa stage, which may last two to four weeks. The pupal skin then splits and the adult beetle emerges. The adult is also carnivorous, but chews its food with the mandibles and digests it internally.

The details of the life cycle differ in other water beetles, even in some other dytiscid species. The larvae of gyrinids and some hydrophilids have a fringe of tracheal gills along each side of the abdomen by means of which they obtain oxygen dissolved in the water. Consequently, they do not need to go to the surface for breathing. Gyrinid larvae are principally carnivorous and probably feed in a similar manner to *Dytiscus*. The larvae, as well as the adults, of hydrophilids are predominantly vegetable feeders and live on aquatic algae. They are less active and slower swimmers than the carnivorous forms.

Adult water beetles all need to obtain air at the surface and cannot live indefinitely if denied access to the surface. Air is stored under the hard wing-covers or elytra which cover the abdomen, so that a considerable period can be spent below—several days in one species. It is not known how those species which live below surface ice obtain their air. Air in the "storage tank" below the elytra can pass directly through the spiracles on the abdomen which are also concealed under the elytra.

In contrast to the dytiscids and hydrophilids which only come to the surface to renew their air supply, the adult gyrinids spend most of their time floating on the surface, where they often congregate in numbers. If pursued they may dive to the bottom but often prefer to skate swiftly along the surface. The gyrating or whirling path they follow when swimming has given them the name of "whirligig" beetles. At other times, however, they swim slowly so as merely to keep pace with the current. An adaptation to the floating way of life of the gyrinid is to be seen in the eyes. Each eye is completely divided into separate upper and lower sections, giving the effect of four eyes. The two lower sections are used for vision below the surface, while the upper divisions are so placed as to serve for vision in the air when the insect is floating. The numerous facets of which the eyes are composed differ structurally in the upper and lower sections, the lower ones being apparently adapted for viewing near objects, the upper aerial ones for more distant objects.

Menotaxis

Many water beetles share with numerous other insects a tendency to swim or move so as to maintain surrounding objects in the same position in their field of vision. Such movements are termed menotaxis. We may express this differently by saying that these insects may strive to maintain a constant rather than a changing visual pattern. As an example we may take a dytiscid water beetle which is swimming in a glass container, around which a series of black and white vertical stripes are rotated. The beetle swims round and round remaining opposite the same stripe, so to maintain an unchanging pattern before its eyes. In a running stream these reactions are of value to the insect, for it tends to keep the same surroundings in view and swims so as to resist being swept away by the current to an unsuitable environment. In gyrinids whirling about on the surface of the water the reactions are undoubtedly more complex. Though they must have a constantly changing view of their environment it has been shown that they still maintain their position by recognition of the surrounding pattern. Not only water beetles, but also certain aquatic bugs such as back-swimmers (Notonectidae) and water-skaters (Gerridae), avoid being swept downstream by the same kind of reactions. It should be realised that menotaxis is not an unvarying reaction of these insects, but takes place when the behaviour is not influenced by other factors, such as the presence of a potential enemy.

A phenomenon related to menotaxis is the attraction to light of night-flying insects, among which we may number the water beetles. This reaction, called phototaxis, consists of maintaining the source of light directly in front of the insect so that it flies straight towards it. At times the source

The larva of a dytiscid water beetle.
Photo.—G. C. Clutton.

of light may be approached at an angle so that the insect spirals round the light as it approaches it.

Capacity for Learning

Experiments have shown water beetles to have moderately developed powers of learning and memory. Dytiscids have been taught to associate certain artificial scents with suitable or unsuitable foods. In these experiments they were not attracted to the scent associated with distasteful food but readily attracted to the scent associated with good food, even after the food was removed. Such learning can be retained for several days, after which the "lessons" are soon forgotten. Gyrinid beetles have been trained to respond to waves on the surface of the water produced by a tuning fork when these were associated with food. The stimuli are apparently detected by special sense organs on the antennae of the beetle. These organs, called Johnston's organ, are particuarly well developed in gyrinids and, as the antennae are held in contact with the surface during swimming, they probably pick up a variety of different surface vibrations and may be used in preventing collisions when the beetles are swimming together.

Because of the ease with which water beetles can be kept alive in an aquarium they are very suitable subjects for behaviour studies. Although much has been written on the subject in scientific journals there is still much than can be found out by one who is willing to watch and experiment with these fascinating insects.

Privet Hawk-Moth Caterpillar

The caterpillar of the Australian Privet Hawk-moth.

Photo.—Howard Hughes.

By L. Courtney-Haines

The large green caterpillars of the Australian Privet Hawk-moth (*Psilogramma menephron casuarinae* Walker) are a common sight on hedges during the summer and autumn. When fully grown they are from 4 in. to 5 in. long, adorned with oblique yellow and lilac lateral stripes and, like other members of the family Sphingidae, have a serrated tail-horn. Should the animal be in any way alarmed a sphinx-like attitude is adopted, and it is from this habit that the family name is derived.

Although caterpillars of the Australian Privet Hawk-moth superficially resemble those of the European Privet Hawk-moth (*Sphinx ligustri* Linnaeus) the moths themselves are distinctly different. The latter has brownish forewings, rose-coloured hindwings and a rose-banded abdomen; the former is mainly grey, the forewings marked with black and the hindwings an overall shade of brown. The view expressed by the late Mr. K. C. McKeown, in his "Australian Insects", that the European Privet Hawk-moth had been introduced into Australia, appears to be erroneous, the author apparently confusing it with the indigenous privet-feeding species.

In addition to the common and variegated privets, caterpillars of *P. menephron casuarinae* feed on introduced garden lilac, pink bignonia, tecoma and American claret ash (*Fraxinius*). The only native food-plant yet discovered is *Notelea longifolia,* a shrub with bluish-green leaves. It has been observed that those caterpillars which feed on common privet rarely attain the moth stage, for just as they are fully fed, and about to go down to the surface soil to pupate, a virus disease kills them.

The moths are crepuscular and nocturnal, and are attracted to various garden flowers, among which petunias and honeysuckle are greatly favoured. The females, somewhat larger than males, may have a wing span of 4 in. or more, and when alarmed are capable of producing an audible squeaky-rasping sound, which is quite startling and is no doubt some protection against enemies.

RABBIT-EARED BANDICOOTS OR BILBIES

By A. E. NEWSOME
Biologist, Northern Territory Administration

RABBIT-EARED Bandicoots are delightful medium-sized marsupials with bluish-grey fur, often with a pinkish tinge, and with long ears. Two of the described species, *Thylacomys lagotis* and *T. minor*, have tails with the proximal part black, the distal white. *T. leuceurus* is described as having a pure white tail. All these are very odd characteristics for a bandicoot, but, even more strange, these animals live in burrows.

So aberrant is this genus compared to other bandicoots that it is thought that it must have diverged from the main Peramelid stem a long time ago. Bilbies have an entirely inland distribution and are characteristic of the Eyrean fauna. If they have always been inhabitants of the arid areas, then we can argue that arid or semi-arid conditions must have been a feature of the Australian climate for a very long time, stretching well back into the Tertiary.

T. lagotis, the largest of the three named species, had the widest distribution. It is known from western Queensland, central and western New South Wales, north-west Victoria, central and northern South Australia, central-western Australia and the drier parts of the Northern Territory. It is now reported extinct in New South Wales, Victoria and South Australia. Recent records of its occurrence come from Birdsville, Queensland, the Blackstone Ranges in central-eastern Western Australia, Woodstock, near Marble Bar in Western Australia, and from some 36 localities in the Northern Territory, where a recent study has shown its distribution to be confined to the Mulga (*Acacia aneuria*) and Spinifex (*Triodia* species) ecosystem.

T. minor is very similar to *T. lagotis* morphologically, but is smaller. It is known from Charlotte Waters and Barrow Creek in the Northern Territory and from the Lake Eyre basin. No specimen of this small species has been taken since the 1930s.

The Rabbit-eared Bandicoot *Thylacomys lagotis*.
Photo.—Australian News and Information Bureau.

T. leuceurus is known from one skin only, sent to Oldfield Thomas at the British Museum from an unknown locality in South Australia about 1880. Its distinguishing feature is its pure white tail. While no further specimen of this species is obtained, its status must remain in doubt.

The most pressing problems confronting an animal living in the arid regions are how to obtain sufficient water, how to escape exposure to excess heat, and how to dissipate excess heat. The Bilbie is reported as eating mice and insects. Its chief item of diet in Central Australia has been found to be termites. In the absence of free water (which occurs only after rains), the Bilbie presumably obtains sufficient water from this food. It is entirely nocturnal and lives in the micro-climate of a burrow from three to six feet deep during the day, thus escaping the intense solar radiation. In fact, the Bilbie is ill-equipped to withstand an intense heat load. It has no sweat glands and it does not pant. Its only mechanism of losing heat is by physical means, aided by vaso-dilation in its very long thin ears and in its muzzle. Captive Bilbies suffered from heat prostration after only 10 minutes' exposure to temperatures above 100°F. in the Alice Springs district.

In common with many Australian mammals, very little is known about the ecology of Bilbies. A study of *T. lagotis* in Central Australia at present under way is aimed at elucidating a few aspects of how this species lives. The species is sparsely distributed. Only four localities where it occurs are known in an area 50 miles long and 30 miles wide—an area extensively travelled by the author. Two other recorded sightings of the species are known inside this area. Compared with the comments of Baldwin Spencer during the Horn Expedition to Central Australia in 1894, the species seems to be less common now than then. He recorded that "its burrows abound". It would appear that the species is disappearing all over Australia. Many people have tried to explain this, but not enough is known of the species' ecology to provide any background to answer the question of why it is apparently extinct in some areas and disappearing in others.

The usual explanations for this disappearance are competition for burrowing space from rabbits and predation by foxes, and some people claim that marsupials as a group are on the wane, anyhow. There are also such factors as long-term fluctuations in the numbers of animals.

Since the Bilbies and some other of these "declining" marsupials survive in uninhabited and undisturbed areas too isolated or too arid to permit pastoral activity, more and more people are coming to think the explanation for the disappearance of some of the smaller species of marsupials is linked with land use. It is hoped the present study may help answer this problem.

NOTES AND NEWS

ABORIGINAL STONE IMPLEMENTS

Mr. Percy Gresser, of Bathurst, has presented to the Museum a collection of more than 5,000 stone implements which he collected on over 100 camp sites of the Aborigines in western New South Wales and western Queensland during the past 48 years. As many of the localities were not previously represented in the Museum's collection, nor, in fact, in any museum's, Mr. Gresser's collection adds considerably to the range of types and their distributions in this Museum's study material. It contains many new distributional records of specialized stone implements, including the *Bondi* and *pirri* points, geometrical microliths, *tula* adzes and the *Burren* adze slug, *juan* knife, *Morella* polishing stone, cylcons, axes, knives and chisels with ground edge, flake fabricators and others. There is a particularly fine series of implements from a number of camp sites in the Condobolin district of New South Wales, and Boulia and Hughenden in Queensland. The geometrical microliths in the collection constitute an amazing range of types, varying from tiny, perfectly made specimens a quarter of an inch long to others up to two inches long. Very little is known about the distributions of stone-implement types in Queensland, and Mr. Gresser's lifelong hobby, the results of which he has given so generously to science, will fill-in many of the blanks in this respect.

RESEARCH

Mrs. Therese Belleau Kemp, formerly of Harvard University, U.S.A., and now living in Sydney, has begun work on the typology of the Aboriginal stone implements of Tasmania. She is making an intensive examination of the Australian Museum's collection as the initial part of this research.

SWAIN REEFS EXPEDITION

The Australian Museum will send an expedition to the Swain Reefs in October to make comprehensive collections of the marine fauna of this large, practically unknown area of the Great Barrier Reef. The Sydney firm of David Jones, Ltd., is financing the expedition, which will include five Museum scientists and a number of other collectors, most of whom are specialists in skin-diving and marine photography. It is planned to spend at least two weeks in the Swains, using one of the coral cays known to exist there as a base. Collecting will be done on the reefs and by dredging and trawling in the deeper water, with the aid of several small boats. The expedition will use a wide variety of collecting techniques, with the aim of making the collections as complete as possible in the time available and covering all groups of marine animals.

A contemporary view of the part of Sydney near where John Roach, "the rascally bird-stuffer," lived. From Delessert's "Voyages dans les Deux Oceans," 1844.
Photo.—Mitchell Library, Sydney.

JOHN ROACH AND THE BUDGERIGAR

By TOM IREDALE and G. P. WHITLEY

WHEN assembling the archives of the Australian Museum, an early reference was found to a bird called Budgerry, nowadays well-known as the Budgerigar. The reference appeared in a book published in Paris in 1847, entitled "Souvenirs d'un Voyage à Sydney (Nouvelle-Hollande) fait pendant l'année 1845", written by Eugène Delessert. The name Delessert was familiar, as Eugène's father, Benjamin Delessert, purchased the famous Lamarck shell collection, but the name of the bird was not, so we decided to investigate closer, little imagining the trouble before us.

The reference was about a bird-dealer and a very early employee of the Australian Museum called Roach, who had an aviary in Sydney and also sold stuffed birds, being a taxidermist of note. Our translation is as follows:—

A man named Roach, who has a great reputation as a bird-stuffer, and who receives numerous orders from Europe, keeps a curio-shop in Hunter Street, worthy of attracting the attention of strangers, particularly those who, making only a short stay in Sydney, haven't the time to go into the surrounding bushland. At Roach's, one can have the pleasure of seeing all at once a selection of the animals found in New South Wales . . .

But the parrakeet which is the tiniest, rarest, and consequently the favourite, is the one called budgerry. It is the size of a canary, clear leaf-green in colour and striped with black on the back. Nothing is more amusing than to hear it chatter and ask for a piece of bread. It is a bird which can be taught without too much trouble.

John Roach, "The Rascally Bird-stuffer"

The Roach mentioned by Delessert as a taxidermist and listed as John W. Roach in early Sydney directories was almost certainly the John Roach who arrived as a convict aboard the "Aurora" late in 1833. In the Parliamentary Archives, Sydney, a letter from E. Deas Thomson to the Colonial Secretary, dated Council Chamber, Sydney, May 2, 1834, reads:—

Sir,

The Prisoner named in the margin (John Roach, per "Aurora") having been employed since 16th January last, in preserving the Birds and other Curiosities in the Museum, I have to request that His Excellency the Governor will be pleased to sanction his being allowed at the rate of 1/9 a Day in lieu of Rations and Clothing, to commence from the above date.

I have also to request that His Excellency will authorise an allowance for the same period at the rate of £10 per annum to William Galvin the messenger of this Office, who has had charge of the Museum for nearly three years.

I have been under the necessity of purchasing from time to time various articles for the preservation of the Birds, for which I will submit an account for His Excellency's approval.

I would also take the liberty of suggesting that the Institution be called the "Australian Museum[1]", and placed under the management of Trustees, to be nominated by His Excellency the Governor; and that another Prisoner of the Crown, be employed under their direction to collect Birds, and other Curiosities,—Roach being retained to set them up, and place them in the Cases, in which he appears to be expert.

It will be necessary that during the winter months a Fire should be constantly kept in the room appropriated to the Museum. I beg therefore that the necessary orders may be given to the contractor to supply the usual quantity for one fire during that period.

Such of the Bird Skins left by the late Curator[2], as were in sufficient state of preservation, have been set up and it will be necessary to purchase cases to place them in, for which I have to request that His Excellency will authorise an advance of £20 to be hereafter accounted for.

I have, &c.
E. Deas Thomson
Clk: Col.

Although a humble convict, John Roach was evidently a keen ornithologist and taxidermist for his times and, presumably, would have been trusted with firearms, for he was employed to collect and preserve specimens at 1s. 9d. a day. A further letter from E. Deas Thomson, dated September 6, 1834, is as follows:—

The earliest picture of the budgerigar—from "Naturalist's Miscellany," by Shaw and Nodder, 1805.

The Auditor General
&c. &c. &c.

Sir,

In reply to your Letter of the 29th Ultimo, I have the honour to inform you that on enquiry of the Colonial Secretary, he informs me that the prisoner named in the margin (John Roach) attached to the Australian Museum, was ordered to be supplied with rations during his absence at Moreton Bay, namely from the 19th May to the 23rd ult°. inclusive but not with any clothing.

I have &c.
(Signed) E. Deas Thomson
Clerk of the Council.

Along with other convicts, Roach, "the man from the Museum", was attached, only the day before it set out, to Major T. L. Mitchell's expedition into inland south-eastern Australia in 1835-1836. (Havard, 1936, "Journal and Proceedings of the Royal Australian Historical Society", 22 (2), pp. 107, 110, 114 and 115). As "Collector of Birds", he was issued, with the rest of the men, with new "grey trousers and a red woollen shirt, the latter article, when crossed by white braces, giving the men somewhat of a military appearance." Otherwise, Mitchell's book tells us little directly about Roach. (Mitchell, 1838, "Three Expeditions into the Interior of Eastern Australia", vol. 2, pp. 2, 22, 25 and 301).

He was apparently not paid for his services—convicts were considered to be privileged to give freely of their labours and share all the considerable dangers and discomforts of a long expedition into unknown country as part of their rehabilitation.

In the accounting for Mitchell's expedition in Sydney in December, 1836, the collection was handed to Dr. George Bennett, the custodian of the Australian Museum, while John Roach, who was "still in servitude" had the sum of £5 deposited in the Savings Bank for his benefit until he became free or obtained his ticket-of-leave.

Surgeon Stapleton, in his MS. Journal, speaks of Roach as the "rascally bird-stuffer" and the "rascally protegee of Mr. McLeay" during Mitchell's expedition to the Darling and Murray Rivers.

In 1837, according to George Bennett's "Catalogue", John Roach was back at the Australian Museum as "Collector and Preserver of Specimens" and in that year, his ticket-of-leave being due, he was granted "an annual salary as a servant of the Institution" on Bennett's recommendation. (Australian Museum letter book, i, 1837, p. 21; salary £5 a month, ibid., p. 32.) Roach continued as such into the 1840's, perhaps later[3], sharing his title with W. S. Wall, also known as "Collector and Preserver of Specimens", if not being replaced by Wall. This probably led to rivalry or friction, for on September 8, 1846, a letter from Lynd, Hon. Secretary of the Australian Museum (Australian Museum letter book, i, p. 68), reported to the Colonial Secretary that John Roach had removed the foetus of a dugong or "Sea Pig" from the Moreton Bay steamer, consigned to Wall as Curator of the Australian Museum by Pilot Hexton, stationed at Moreton Bay. Roach had represented himself as the Curator and took the foetus from the ship, surely one of the oddest thefts in Sydney's lengthy catalogue of crime! The specimen was subsequently recovered by Wall, and the matter placed in the Law Officer's hands for Roach's due punishment.

A little earlier, in 1845, there was a John W. Roach at 32 Hunter-street, listed as an "Ornolhogist" in Low's "Sydney Directory" of that year[4] and in 1847 as John William Roach at the same address as a taxidermist (Low's "Sydney Directory," 1847). Again, in 1851, there was a John William "Roche" at the Rainbow Tavern, Pitt-street north and King-street east (Ford's "Sydney Commercial Directory", 1851; "Sydney Morning Herald", August 26, 1961, p. 12). Doubtless all these references concern our man, whose private residence might easily have been in Hunter-street in those days.

There was a story that a Mr. Roach, of Petty's Hotel, gave a collection of insects to the Governor, who placed it in a round-house (or watch-tower), perhaps the one in Cumberland-street, in the charge of W. S. Wall. This seems unlikely in view of the foregoing facts. In 1836, the proprietor was "Thomas Petty, late of Pulteney Hotel" ("Sydney Gazette" newspaper, July 9, 1836, p. 3), which was in Bent-street.

According to W. W. Froggatt's "Australian Insects" (1907, p. 412): "The Australian Museum, Sydney, was founded in 1836 and incorporated by Act of Council in 1853. The first collection of insects was made by Mr. Roach of Petty's Hotel about 1835, who presented it to the Government; they were exhibited in the 'Round House' near Circular Quay, where they were placed in charge of W. S. Wall, afterwards the first Curator of the Australian Museum."

The last we can trace of J. W. Roach is an address at the German Club, Wynyard Square, Sydney ("Sydney Directory", 1858, p. 195), where he was a steward and proprietor of the club ("Sydney Directory", 1861).

Budgerry or Budgerigar

After this historical circumlocation we come now to Delessert's early use of the name Budgerry for one of Roach's birds, now known as Budgerigar (*Melopsittacus undulatus*).

Psittacus undulatus first appeared in literature in 1805, when Shaw and Nodder ("Naturalist's Miscellany", 16, pl. 673) figured the bird from New Holland with a made-up vernacular of Undulated Parrot. Their specimen apparently was a straggler towards the coast near Parramatta or Sydney, as it is an inland-living bird. As late as the 1830's not much was known about the species, so Gould, before he came to Australia, issued a plate of it.

Charles Barrett stated that one was "shot out Rose Hill (Parramatta) way in 1804", but did not give the source of this information. The specimen may be the one in the Linnean Society of London, as Latham (1824) reported one in that collection and only two others, one in the collection of General Davis, the other in Mr. Harrison's.

Gould met with the species on the Liverpool Plains in March, 1839, but before that, in the British Cyclopaedia of Natural History[5], issued before June, 1837, furnished the following information (Vol. 3, p. 414): "The species to which we allude is the waved or undulated one (*Nanodes undulatus*). It is a pretty little bird, about seven inches in length, of which the tail occupies half. The general colours are greenish, yellow, and brown, with blue on the middle feathers of the tail, which are very much produced; and there is a small patch of blue on each cheek. This handsome little bird is very common in New Holland and Van Diemen's Land, and appears as often upon the ground as on trees".

The late Percy A. Gilbert wrote a note on "The Vernaculars of *Melopsittacus undulatus*, Shaw" in 1941[6] and gave a chronological summary of the names which (apart from English vernaculars) were:—

1847, Betshiregah, Leichhardt.

1848, Betcherrygah, Gould (should be 1840), native name, Liverpool Plains, where Gould was in March, 1839[7].

1849, Bidgerigung, Sturt.

1850, Bougirigard, Huxley.

1870, Budgerigar, accepted modern spelling, Cassell's "Household Guide".

1889, Budjerigar, Newton, Dictionary of Birds, 1893.

Budgerrygar of standard works and check-lists.
Budgerygah.
Budgerigah.
Buderigar in an American publication.
Budgereegah.

1896, Beauregard, Newton, 1896 (Dict. Birds, p. 59).

Betcherygah.
Boodgeree-gar.
Budgee, Budgie (newspaper articles and vulgar speech).

In 1960 Mr. Gilbert handed us two additions to his list: Budgere Gar—from "Bush Wanderings of a Naturalist, by an old Bushman", i.e., H. W. Wheelwright, 1865, p. 167 (also in the first edition of 1861)—and Budgereegah, Budjerigar, Webster's Dictionary, 1928 edition.

Webster, in the supplement to his 1902 dictionary, prefaced 1900, page 30, gave various other spellings, of which Budgereegah was preferred in Brown's "Words".

Austin[8] and Sanford gave Budgerager and Bugirigar from Western Australia in 1855. Near the top of the list of more than 20 variant spellings of budgerigar should come Delessert's budgerry for Roach's bird.

Not for nothing do we refer to "natural history" as the study of animals and plants. The naturalist must be a historian as well, and finds he must follow up every clue when studying his subject. We little thought, when we read a paragraph or two in Delessert, that we should be led so far astray.

[1] This appears to be the earliest reference to the name "Australian Museum". The collection was then housed in the Council Chamber, Macquarie Street, now Parliament House.

[2] This would have been William Holmes, no doubt. See Whitley, "Australian Museum Magazine", March, 1961, p. 306.

[3] Tegg's "N. S. Wales Pocket Almanac and Remembrancer for 1840", p. 141; 1841, p. 168; 1842, pp. 153-4.

[4] See also John Askew, 1857, "A Voyage to Australia and New Zealand by a Steerage Passenger", p. 197: "In Hunter Street there is a Museum of Natural History. This place has a shop front, and the window contains beautiful specimens of preserved animals".

[5] In three volumes, London: W. S. Orr & Co., Amen Corner, Paternoster Row, 1835, 1836, June 1837. Edited by Charles F. Partington [from Articles] by Authors Eminent in their Particular Departments.

[6] Gilbert, 1941, "Proceedings of the Royal Zoological Society of New South Wales, 1940-41", p. 44.

[7] Misled by Morris's "Austral English" (p. 61), Gilbert dated Gould's name from 1848, placing it second to Leichhardt's, but Gould's comes first, having been issued in 1840.

[8] Austin, 1855, Journal of Assistant-Surveyor R. Austin . . . expedition to explore the interior of Western Australia. Small folio, Perth, Western Australia, 1855. Appendix, W. A. Sanford to Robert Austin, p. 49 (includes undulated grass parrakeet or bugirigar).

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