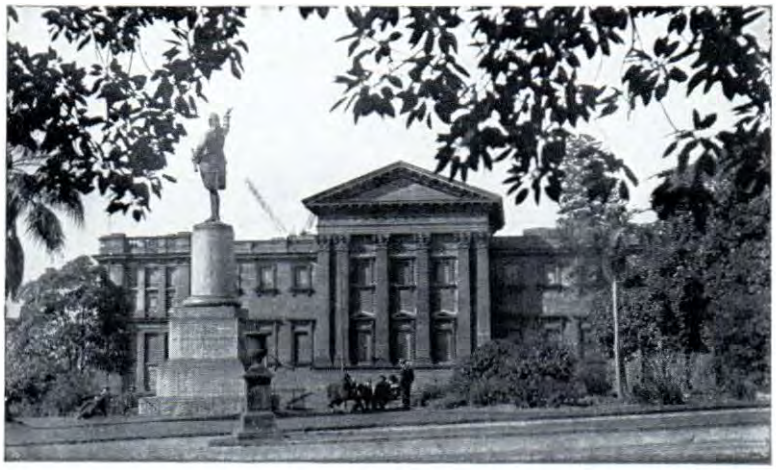
AUSTRALIAN NATURAL HISTORY

PUBLISHED BY
THE AUSTRALIAN MUSEUM
SYDNEY

Registered at the General Post Office, Sydney, for transmission by post as a periodical

JUNE 15, 1966
VOL. 15, NO. 6
PRICE, THIRTY CENTS



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● **FRONT COVER: The Veined Sun Orchid (*Thelymitra venosa* variety *magnifica*), of New South Wales, usually grows on rock ledges in mountainous country. Its exquisite blue flowers are up to 1½ inches in diameter. It is a protected plant, and not easily cultivated. The photo is by David K. McAlpine, whose article on New South Wales orchids appears on page 174.**

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Published Quarterly by the Australian Museum - - - College Street, Sydney

Editor: F. H. Talbot, M.Sc., Ph.D. Annual Subscription, Posted, $1.40

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Unknown Australia

By A. J. MARSHALL

Department of Zoology and Comparative Physiology, Monash University, Victoria

THERE remains, of course, no part of the continent of Australia that is still truly unexplored. It is probable that there are restricted bits and pieces of central and north-western Australia that whites have not penetrated, but even that is doubtful. Ever since the first coastal settlements were established, odd, specialized men (usually, but not always, mineral prospectors) have wandered into the unknown with a horse, a gun and a bit of tea, sugar and flour. Men like these generally made no maps and they discarded no bottles and jam-tins. They were not given to carving initials on trees, nor even building cairns.

So it is probably true that there is hardly a single valley in this continent over which someone has not gazed, even though he may not have actually walked there. The prospectors went off into the loneliness and most of them came back empty-handed. Usually they told no one where they had been. The fleeting traces they left behind them—tracks and old camp-fires—were washed out by the next monsoonal rains. Last year, in the remote northern Kimberleys—between the last cattle stations and the beaches of the Timor Sea—members of the Monash University Expedition saw not a single sign of former white occupation.

No brown men are living in the bush there either, yet almost everywhere we saw traces of a former flourishing existence. One place in particular I remember very vividly. It was the dry season, yet out of the valley floor came a small spring of clear water. The water made a tiny stream in which blue water-lilies were growing. Marking its course were slender paper-barked cajeput trees and pandanus palms. There were plenty of birds and Grey Wallabies in the valley, and Rock Wallabies lived in the tumbled outcrops of sandstone above. The former Aboriginal population had plenty of food and water, and good shelter under the rock ledges from the tropical heat. In the sandstone floors of the shelters were smooth depressions where the Aborigines had ground up nardoo or other seeds. And while the women worked, the men had covered wall after wall, and some ceilings too, with their art. They had always chosen shelters through which the cool prevailing breezes blew. The rough sandstone floors

The King Edward River, northern Kimberleys, Western Australia.

were worn marble-smooth where they had rested from the heat outside. I named this place the Painted Hills.

Aboriginal art

The other biologists went about their jobs of collecting reptiles, wasps and freshwater organisms while my wife and I clambered over the rocky outcrops in search of pictures. Her job was to collect plants, and to copy drawings that were in positions difficult to photograph. The higher and cooler shelters were obviously special picture galleries, but many other places were adorned with odd scribbles here and there. We saw pictures of snakes, crocodiles, wallabies, tortoises, and the outline of a left hand. It is said that the Aborigines anticipated the modern spray gun in making this sort of hand picture. A man would chew up pigment and then place his hand flat on the rock. Then he blew the pigment and saliva against it to form a stencilled outline.

Some of the pictures were very old. Among the most ancient were spirited interpretations of animals and dancing warriors done in a dark blood-colour. Of the same age, too, were some curious little soldierly figures that we found puzzling. These old pictures, by and large, did not photograph well, and were often veiled by the streams of brilliant iron-red, and black and white encrustations, that had leached out of the rocks. The rocks themselves were lovely in flowing and curving strata. Some were coloured like watered silk, varying from pale cream through pinks to a deep heliotrope. With the addition of iron stains and the paintings the effect was extraordinary.

In some places more modern pictures had been superimposed on the older ones. Altogether, there seemed to be at least three periods. One was represented chiefly by several grotesque Wandjina spirits with ghostly white faces, each marked with dark eyes and surrounded by a decorated halo of hair. These were without mouths. Pictures of this kind have been found in several parts of the Kimberleys, where they were first discovered by the explorer Sir George Grey in 1837. The face is said to represent a human skull, and Aborigines have told anthropologists that, since the Wandjina spirits do not talk, they have no need of mouths.

The Wandjina spirits were said to be rain-makers and were customarily repainted before the start of "the wet". Some have said that if the spirit faces were not repainted there would be no "wet". If this came to pass the streams would not run. And so the wild ducks would not come, the other food animals would move away and the tribe would face a lean year.

Influenza epidemic

And now, these artistic people have left this fertile land. Apparently there were plenty about until just after the First World War, when the deadly so-called Spanish influenza epidemic wiped most of them out. This pandemic swept the world, and caused more deaths than had all the guns of both sides put together. Not even in these remote areas were men safe from the rampaging virus. The Aborigines and the Pacific Island peoples were horribly vulnerable to the white man's diseases. Measles, a disease that is only rarely troublesome to us, wiped out 40,000 Solomon Islanders in a single epidemic during the last century. Such people have no inbuilt resistance to diseases that are new to them, any more than pioneering whites have a native resistance to malaria.

The Aborigines who survived the influenza epidemic gradually drifted away, and today their children work on cattle stations and missions. The country still swarms with fish and game but the land is empty of Aborigines, and only their art and a few discarded implements remain. The Aborigines live in reasonable contentment with the white man. It is easier to get sugar from the store than to climb trees and chop out wild honey, and simpler to open a can than to hook the wily river barramundi or stalk and kill a kangaroo.

It is problematical how long these charming pictures will endure. Many of the better sheltered ones, and especially the staring white-faced Wandjina spirits, looked as though they were painted almost yesterday. Others had been sadly defaced by wind, water and mineral seepage and encrustation. All that we could do was make a precise map of their situation so that anthropologists can locate them in the future without waste of time.

Above: An Aboriginal painting of a Wandjina spirit. Below: A hand stencil made by an Aboriginal placing his hand flat on a rock surface and blowing a mouthful of pigment against it.

Opportunity of future study

The whole of this wide north-west is a treasure house for future scholars. The tragedy, of course, is that in a very few years from now all the old men, who remember the last pictures being made, will be dead. And so there will be no first-hand recollections of how and why the paintings were made, and precisely what they mean. It is to be hoped that the admirable Australian Institute of Aboriginal Studies will find time, and the necessary money, to fit an investigation of this area into its no doubt already overcrowded programme.

Even though the Aborigines have gone, the country is still full of game. The rivers were full of barramundi and "trout", and bustards or plains turkeys (verging on extinction everywhere else) stood watching our trucks from a distance of a few yards. There were wallabies of various sorts in plenty, both in the scrub and on the cliff faces. Big wallaroos crashed heavily along the creeks. Yet only a few small mammals —native mice and rats—entered our traps, and we wondered why. The probable reason for this is the astonishing prevalence of the common domestic cat. We saw tracks of many, and found one dead.

It was strange to find *Felis domesticus* in an uninhabited part of Australia. This country, outside the central deserts, is one of the few parts of Australia that is uninhabited by man—brown or white. It is also one of the few places into which the imported fox has so far failed to penetrate. Yet there are feral domestic cats in plenty. They are probably the descendants of those kept by the former Aboriginal population, and of those that chose to remain on abandoned cattle stations nearer civilization. Mr Fred Russ, the owner of Gibb River, the most remote cattle station, told us, on the other hand, that forty years ago tribal Aborigines told him that cats were native to the area. This, of course, is not true. Before the coming of ships, the only mammals of this sort in Australia were native rats, bats and the dingo. According to Mr Russ, however, there is a faint possibility that, long before the white man came, Malays had traded domestic cats to the coastal populations of Aborigines.

Vine forests

A few days later the helicopter picked us up at the base camp and flew four of us, in two relays, into northern vine forests. Now, for the first time, we were in an Australia that is virtually unknown.

We clattered along just above the tree tops. We flew past running rivers that had been mapped by means of aerial survey, but are still waiting for names. Brilliant honey parrots and black and white butcher-birds burst excitedly from the gums and grevilleas as we went by. At this level we seemed almost to march up the hills with the tree-tops, keeping the same distance as we went down the other side to the timbered plains. About three miles from the Timor Sea we

Aboriginal rock paintings.

saw, crouched under a range, patches of vine forest.

The pilot circled the helicopter around. The patches of bright-green tropical forest were strung along under the cliffs of a wide valley. Millions of years ago, forest something like this had stretched from Cape York right across tropical Australia. In times gone by, too, Torres Strait did not exist and so Cape York and New Guinea were joined. Then had come arid phases of climate, and the rain forest between Cape York and north-western Australia had been obliterated as the grey-green battalions of gum trees and wattles had slowly marched in.

Today, the former rain forest exists in the north-west only as relict isolated patches of tangled vine forest clinging to the hillsides below the steep cliffs. Here it gets the advantage of a small amount of seepage from the hills, and the nutrient minerals that the seepage carries.

These isolated remnants, then, are a tangly, rather unpleasant kind of "dry" rainforest, which of course sounds, and is, a crazy contradiction in terms. Because these green spiky forests have been so long isolated from the nearest true "jungle" on Cape York, we were extremely keen to discover what would be living in them today.

There was no chance of landing near the vine forest under the cliffs—and there was no water there either—so the pilot took the helicopter down into the bed of the valley. He hovered momentarily, and then settled the machine on the rock creek bed just above a waterfall. We unstrapped our gear. Then the pilot took off to bring the next pair in.

While our taxidermist set up camp I went uphill towards the nearest patch of vine forest. I had wanted to get into one of these relict places ever since I was an undergraduate. The hillside was covered by grass up to 10 feet high and I had to beat my way through it with the gun barrel. It was not the most comfortable trip I have made, but soon there was evidence that it was worthwhile. One of the first things I saw when I reached the green edge of the forest was a Yellow Figbird, isolated, like the place in which it lived, by about 1,200 miles of gum trees from its nearest relatives on Cape York.

I went through the prickly scrub and climbed up a steep cliff, hanging on once to rest and to reflect that years ago I would have taken this one in my stride. From the top, a wonderful—in the real sense of that much debased word—sight stretched before me. Towards the Timor Sea there were simply grey-green gum trees. Below me was a sea of deep tropical green. Downstream, our unnamed creek dropped into a wide unnamed estuary, lined with acres of mangroves. The overwhelming feeling was one of stark solitude.

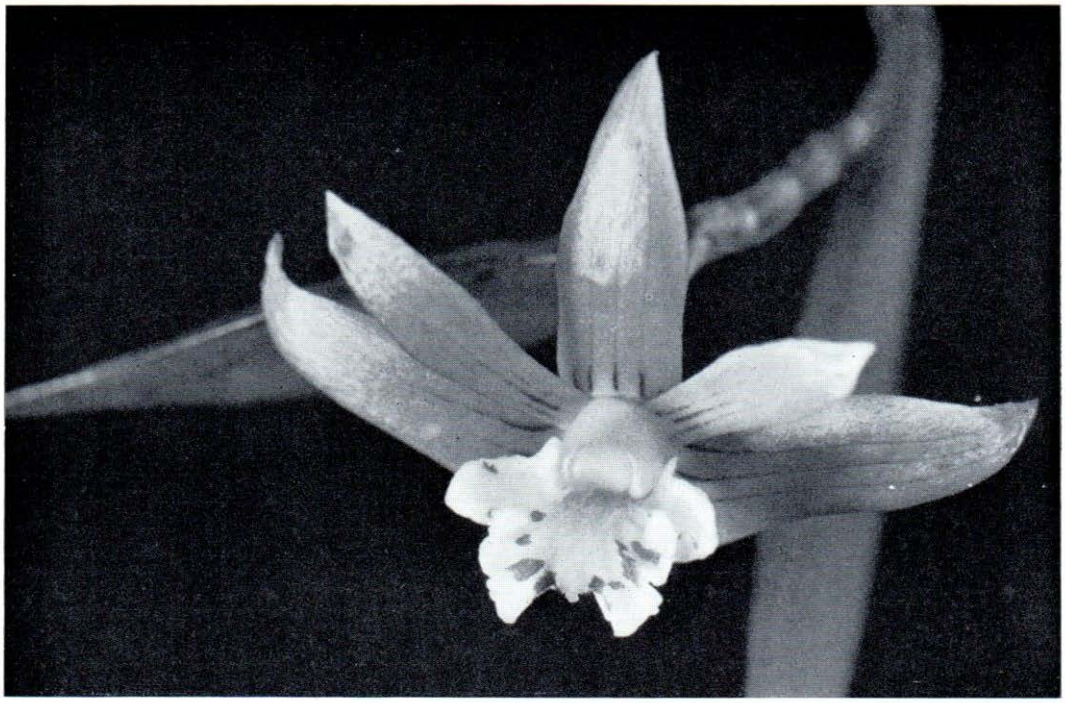
Attack by dingo

Then a curious thing happened. Suddenly a lean tawny dingo broke out of a thicket and ran at me, snarling. Dingoes never attack men. I was so astonished that I let the dingo get within ten or twelve feet before I put a charge of shot into it. I was using only bird shot, which is not lethal to a big dog. It loped back into the scrub, followed by its mate. Even when hit it remained silent: a domestic dog, by comparison, would have yelped from there to Brisbane!

Dingoes never attack men; why, then, did this one threaten me? I believe that the answer lies in the depopulation of the country. Today, the nearest Aborigines live on a mission station perhaps 100 miles away, and so the dingoes of the region have grown up without fear of man. The cliffs here abound with rock wallabies. I believe that this particular dingo recognized me as an extra big, and gratifyingly slow, Rock Wallaby that was begging to be pulled down and torn to pieces.

What will happen to this great desolate land between the Gibb River Station and the Timor Sea? So far it has defeated attempts at settlement and so it remains the last truly unspoiled, yet well-watered, part of our country. The Western Australian Government has, by and large, a good conservation record. It could earn the gratitude of generations to come if it declared this area a national—and natural—reserve in perpetuity.

[Photos in this article are by the Department of Zoology and Comparative Physiology, Monash University, Victoria.]



The Dagger Orchid (*Dendrobium pugioniforme*) is common in wet forests near the eastern edge of the tablelands. It has small pale-green and creamy-white flowers with red markings and thickened, sharp-pointed leaves. It is one of the epiphytes—orchids that grow on the bark of living trees and, in some cases, on rock surfaces. [Photo: A. Healy.]

Orchids of New South Wales

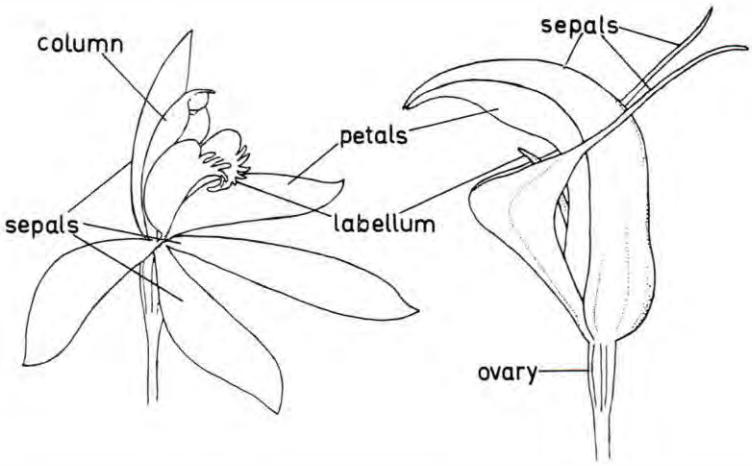
By DAVID K. McALPINE

THE orchids form one of the largest families of flowering plants and undoubtedly the most varied. Though the greater number of species is to be found in the tropics, there are orchids native to most cool temperate parts of the world. In Australia they may be found near the seashore or at an elevation of over 6,000 feet at Mount Kosciusko. The majority of orchids native to New South Wales have small flowers, sometimes quite inconspicuous, but they are still of interest because of their variety of plant form and the often extraordinary structure of their flowers.

Orchids, despite their diversity, can be recognized by certain constant features of floral structure (see diagram). All have three petals, surrounded by three outer segments or sepals, which enclose the flower in the bud. One of the petals is usually different from the other two and is called the labellum. In the centre of the flower is the column, a single structure with both male and female organs—anther and stigma—upon it. The ovary, in which the seeds develop, is situated below the sepals and petals and appears as a swelling in the stalk (pedicel) supporting the flower.

Reproduction

Orchids are highly adapted for insect pollination. So specialized are the flowers



These flowers of two different orchids illustrate variety of structure: *Caladenia alba* (left) and *Pterostylis baptistii*. [Diagram by author.]

of some species that they can only be pollinated by one or very few species of insects. The Leather Tongue Orchids of the genus *Cryptostylis* are only pollinated by males of a single species of Ichneumon Wasp, *Lissopimpla excelsa*. The wasp appears to mistake the flower for a female of its own kind and, in attempting to mate with several flowers in succession, accomplishes the process of transferring pollen. Some orchids have conspicuous insect-like swellings on the labellum which no doubt attract insects capable of pollinating them.

Very frequently the labellum serves the function of a landing platform for insects. It may be hinged at the base in such a way that the weight of an insect upon it causes it to fall against the column (e.g., in the flower of *Caladenia*, illustrated, and the familiar *Cymbidium*). In orchids of several other genera (the Duck Orchids, *Caleana*, and the Greenhoods, *Pterostylis*), the labellum is sensitive to touch and actively springs against the column when an insect settles on it. Many of the more conspicuously beautiful orchids, particularly those with white, yellow or blue flowers, neither resemble insects in any way nor supply the insect with any reward in the way of nectar or excess pollen. Yet these flowers rely entirely on the visits of insects for pollination. We can only assume that these flowers conform to the normal appearance of other flowers, a majority of which contain some reward for the pollinator, and that the latter does not readily distinguish them.

After pollen has come in contact with the sticky fluid of the stigma of another flower, each pollen grain bursts and a fine thread-like tube grows from it through the column to the ovary. The so-called generative nucleus, which contains the elements of inheritance from the male or pollen parent, passes through the tube to unite with the nucleus of one of the ovules in the ovary. The ovary swells to form a fruit as the ovules develop into seeds. Orchid seeds are remarkable for their small size and great number. There may be several thousand seeds, as fine as dust, in a single fruit. When ripe the fruit splits open, releasing the seed, which may be carried some distance by the wind.

Germination of the seed is usually dependent on the entry of a minute fungus called a mycorrhiza. The fungus continues in the roots of the orchid throughout its life, supplying the latter with certain essential substances. Most or perhaps all orchids seem to rely on such a fungus for survival.

Classification

Orchids may conveniently be classified into three main categories from the nature of their growth. Such a classification is not to be confused with a botanical classification which shows the evolutionary relationships between plant species.

1. Terrestrial or ground orchids. These are the most familiar orchids in southern Australia. The roots are always embedded

The Doubletail Orchid (*Diuris aurea*) is a typical terrestrial: it grows from underground potato-like tubers. The yellow flowers are about 1 inch across.

in the soil and typically each plant has one or more green leaves, though these may wither before the flowers develop. Examples are Doubletails (*Diuris*), Sun Orchids (*Thelymitra*), and Greenhoods (*Pterostylis*).

2. Saprophytes. Though strictly speaking these may be classed as ground orchids, they differ from the above group in being leafless and without or with very little green pigment---chlorophyll—in the whole plant. Chlorophyll is essential for the process called photosynthesis in green plants, i.e., the building up of sugars and starches from carbon dioxide and water in the presence of sunlight. Saprophytes cannot synthesize these substances and must therefore obtain them from organic matter in the soil, always with the aid of a fungus growing on the roots which aids in assimilation. One of our commonest saprophytes is the Hyacinth Orchid (*Dipodium punctatum*) with its attractive red-spotted flowers. The fungus associated with this orchid grows on the roots of gum trees (*Eucalyptus*) or paperbark trees (*Melaleuca*) and the orchids are only found under these trees.

3. Epiphytes. Many orchids, including the great majority of the tropical species, grow on the bark of living trees. Without soil for anchorage, the roots cling closely to every irregularity in the surface, making it hard to dislodge them without breakage. Because of the negligible water-holding capacity of the bark, the plants are subject to drying out in unsuitable environments. In New South Wales nearly all epiphytes are restricted to the well-watered eastern parts, particularly the north-east. Epiphytes usually have thickened, bulbous aerial stems, called pseudobulbs, or fleshy leaves, which can hold a reserve of water. Some ephiphytic orchid species grow at times on rock surfaces instead of trees. The King Orchid

An uncommon saprophytic orchid, *Galeola cassythoides*. The small pale-yellow flowers are numerous on much-branched leafless, purplish stems, which often climb on tree-trunks for support.

The Duck Orchid (*Caleana major*) has a mobile labellum shaped like a duck's head. When an insect alights on it, it springs against the column, making pollination possible. The purplish-brown and green flowers of this terrestrial orchid are about 1 inch in height.

The Onion Orchid (*Microtis parviflora*), a terrestrial with minute green flowers, is abundant in many areas near Sydney.

or "Rock Lily" (*Dendrobium speciosum*) grows in tree-tops in the rain forests, but in the sandstone areas around Sydney it grows on the tops of rocky outcrops. Some species, called lithophytes, are confined to rock habitats.

Vanishing orchids

Within the last twenty years the writer has noticed a sharp decline in the native orchid population of New South Wales, both in the vicinity of Sydney and in country areas. This is only partly due to destruction of bushland, for the decline extends to undeveloped lands and even flora reserves. At the same time immense interest has been aroused in the cultivation of Australian native plants, and many societies have been formed throughout the State for the benefit of those wishing to grow orchids. Some of these societies specialize in native orchids and most include native orchid sections in their annual exhibitions, where members compete with each other for the finest and most unusual plant. Several big firms compete in the sale of native orchid plants, including species listed as protected plants by State laws. An unknown but probably large number of plants is exported. Of the many plants gathered from their natural habitat it is probable that only a small percentage survive for more than three or four years, to judge from the preponderance of a few hardy species in orchid shows.

Clearly, in only a few more decades the more decorative orchids will cease to exist in the wild state, if present trends continue. It would seem that the most effective method

A Beardy (*Calochilus paludosus*), remarkable for the long purplish hairs on its labellum. The flower is about one inch in height.

for reducing the destruction of our flora is the taking of a firm official stand by all organizations concerned with the cultivation of native plants. Members should be strongly discouraged from taking native flora from the bush. Orchid societies should publicize the great range of improved varieties and hybrids now available from nurseries, which are generally much easier to cultivate than their bush relatives, and yield more spectacular results.

[The photos in this article are by Howard Hughes, except where stated otherwise.]

BOOK REVIEW

"ENVIRONMENT AND ARCHAEOLOGY":

An Introduction to Pleistocene Geography. By Karl W. Butzer, 1964. Methuen & Co. Ltd. Price: $13.10.

Geography is concerned with "man and nature". Pleistocene geography, therefore, attempts to reconstruct the relationship between prehistoric man and prehistoric nature. This book, which grew out of lectures and seminars given at the University of Wisconsin after 1960, brings together an astonishing amount of factual material which could otherwise only be obtained from a very wide reading of specialized technical publications. Its avowed purpose is to encourage an interdisciplinary approach to archaeological and environmental studies.

A brief summary of the contents will give an idea of the remarkable scope of this book. The first part is concerned with the general background to the subject, including ecology, stratigraphy and chronology; part two deals with vegetation, soils, and geomorphology, relating these to mammalian and human distributions. The third part is of particular interest to archaeologists, being devoted to the interpretation of Pleistocene sediments: the next section is an explanation of how the biological sciences can assist in such interpretation. Part five described some Pleistocene environments in various parts of the Old World, concentrating particularly on the effects of the glacials and interglacials; and the final chapters cover the origins, development and spread of the human race.

Unlike most compendiums of this type, *Environment and Archaeology* presents its facts and theories in a very readable way, as well as being an invaluable reference work. Its usefulness is enhanced by an extensive bibliography and an adequate index.

Since it is now becoming clear that the time span for the human occupation of the Australian continent reaches well back into the latter part of the Pleistocene, this book should be in every Australian archaeologist's knapsack. However, it is written and illustrated in such a lucid way that it could not fail also to be of interest to anyone wishing to know how our present environment was formed and inhabited.—*D. R. Moore.*

MUSEUM'S ARCHAEOLOGICAL PROJECT

The Curator of Anthropology at the Australian Museum, Mr D. R. Moore, reports the completion of a successful "dig" by Museum personnel of a rock shelter in the Sandy Hollow area, near the junction of the Hunter and Goulburn Rivers. The archaeological survey of the Hunter Valley, previously mentioned in this magazine, is now continuing in the Singleton district. Any information about promising excavation sites in the Bulga-Milbrodale-Wollombi Brook area would be welcome.

An Aboriginal boy eating a cossid grub from a Witchety Bush at Ooldea, South Australia. Cossid grubs are the larvae of a family of wood-boring moths sometimes known as Goat Moths.

INSECTS AS FOOD FOR THE AUSTRALIAN ABORIGINES

By NORMAN B. TINDALE
South Australian Museum

INSECT foods play an important role in the life of Australian Aborigines, providing their principal delicacy, honey, and a considerable portion of their needs in animal fats, the equivalent of the butter-fat element in our diet.

The earliest pursuit of children, under the guidance of their mothers, is a hunt for various kinds of insect larvae, witchety grubs, and beetles. It is probable that the healthy growth of children in large measure is related to this source of food. Early nourishment of babies prior to weaning is assisted and the children are kept quiet by the cossid and hepialid grubs constantly dangling from their mouths. In our society a dummy replaces this early natural food for children.

Scurvy

In drought years a diminution in the supply of grubs, lerp scales and Honey Ants, along with the disappearance of native greens, may cause outbreaks of scurvy, playing havoc with the health of adults as well as of children. During 1930 there was a serious outbreak of this disease among the Kukatja (Loritja) people west of Hermannsburg, in central Australia. It was relieved dramatically when members of the University of Adelaide Anthropological Expedition of that year provided orange juice for the crippled children and their suffering parents. On that occasion Kukatja women complained bitterly of the disappearance of the grubs from the roots of the *Acacia kempeana* shrubs because of the drought, and of the impossibility of digging for the Honey Ant, which had taken their diminished stores of honey far below the ground.

Every Aboriginal is constantly on the watch for insect food. I have seen a man, who supposedly was engrossed in the stalking of a kangaroo, glance aside at a likely gum tree and turn away from the hunt to test a hole with his spear-point. This led him to make a hooked stick with which he

pulled out a grub similar to the *Xyleutes* illustrated. He ate it, and only then did his attention return to the more serious business of the hunt.

In 1957 I met a family of nomadic Ngadadjara people at Lightning Rocks. They were moving west from the Blackstone area to the Warburton Ranges in Western Australia. For several days they had been living on the sugary scales of the lerp insects which feed on mulga shrubs. Their mouths were sore and bleeding from the great many twigs which had brushed across their lips in feeding. Their teeth were stained with the lac-like secretions of the scale insects. They were in no way concerned at this monotonous diet, but, as a change, were busily engaged in pounding and soaking the dried fruits of the native fig trees which were growing in crevices of the granite rocks.

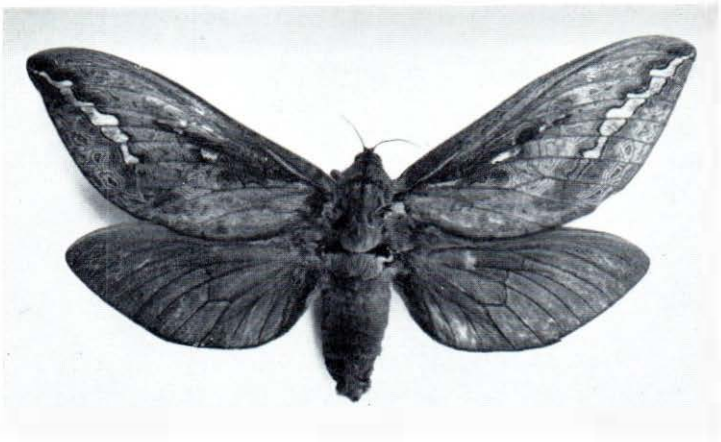
The distribution of hafted stone axes in Australia is determined in large measure by the use made of them in the chopping out of stingless *Trigona* bees' nests. These are found in hollow gum trees, trees often hollowed out by that other insect, the termite, which also is an important article in the diet of Aborigines. Honey gathering from trees is men's work: women are termite collectors. Special digging sticks, spade-like scoops, and pointed hammerstones are the equipment necessary in broaching the termitaria. Live termites are separated from the antbed and other debris by winnowing and by rocking in wooden dishes. Hot ashes and small embers are shaken in the dishes with the termites to kill and cook them. Alternatively, the live animals are pounded together in a dish and kneaded into a raw oily cake.

Green Tree Ants

In Arnhem Land, and along the coasts of the Gulf of Carpentaria, nearly every tree has one or more nests of the Green Tree Ant (*Oecophylla smaragdina*). There are Green Tree Ants foraging for food on every square foot of the ground in that area. Women shake the contents of the leaf nests, eggs, larvae and adult ants, into close-meshed baskets from time to time, crushing the masses of creatures they have gathered. Water is poured through the contents and the liquid collected in a wooden dish or a bark bucket. The result is an acid-tasting drink with a taste somewhat like lemonade, but without the fizz which helps to make our drink palatable.

Most exotic of the honeys gathered by Aborigines is *jeramba* (Aranda tribe word) obtained from the ant *Melophorus inflatus*. This medium-sized black ant is found living in holes beneath mulga (*Acacia aneura*) shrubs growing on silt-covered plains which are flooded temporarily during rare heavy rains. After such summer rains, when new foliage is developing, the ants gather honey

Honey Ants, swollen with honey gathered from flowers and leaf buds, provide Aborigines with one of their favourite delicacies. This photo was taken at Haast Bluff, central Australia.



A female of *Trictena argyrosticha* Turner, one of the species of Ghost Moths that are a classic Aboriginal food in the southern half of Australia.

from the small glands on the leaf buds and from the flowers. They take it down into their nests at depths from 2 to 6 feet in the silty red soil. Certain of their numbers are fed with such large quantities of the liquid that their gasters become swollen into spheres whose diameters are more than twice their original length. These helpless living storehouses of food assist in tiding the ants over the lean years when there is no flowering of the mulga. Aborigines say that after two dry years there is no honey to be gathered by digging out the nests. In normal times a rich supply of food may reward an afternoon's effort by a group of women. They may leave behind them a hole 6 feet across and several feet deep as witness to the gathering of half a pound of honey in its multitude of pea-sized spherical packages.

The Kaiadilt people of Bentinck Island use one large species of plague locust as food. They string the grasshoppers side by side on sharpened sticks until they have sufficient to toast lightly over the cooking-fire. A companion species of grasshopper is despised because of its unpleasant taste.

Ghost Moths as food

One of the classic foods in the southern half of Australia is provided by several species of Ghost Moths of the family Hepialidae. *Abantiades* and *Trictena* are two genera of moths of large size and there are many species of the genus *Oxycanus* which are eaten. The larvae of many of these Ghost Moths live underground as external feeders on the roots of gum trees, and on several species of *Acacia*. When fully grown they may be up to 6 inches in length. They tunnel up to the surface of the ground, leaving a silk-supported film of debris on the surface as a cap to their tunnel. They then pupate deep down in the hole, selecting that place where the humidity level is most suitable, for the animals are very sensitive to desiccation as well as to excessive moisture. The pupae are provided with serrated margins on their abdominal segments, and are capable of movement up to the surface when they are ready to emerge as moths.

Aborigines have learned to detect trees which have been debilitated by the attacks of hepialid larvae, and scrape off the surface soil, exposing the tunnels. They test the holes by smell: the humid ones are those containing living larvae and pupae. A long supple stick with a hook at its lower end is worked carefully down the holes, sometimes to the astonishing depth of 6 feet. The creature is hooked and pulled up. This is a slow and tedious business. A better way to enjoy a feast of Ghost Moths is to wait until the season of emergence of the adults. In desert Australia this will be on the day of the first big rain of summer. In the cooler parts it will be usually the first big rain storm of autumn. Then, as if on cue, thousands of the moths emerge at one time, usually an hour before dusk, fly at the coming of night, mate for up to half an hour and then part. The females lay thousands of tiny spherical eggs, spraying them over the

ground as they fly. A large female may have as many as 50,000 eggs in her body. These she lays all in the one night. By morning the moths lie dead or exhausted on the ground, the whole of their substance, stored in the form of fat, having been burned up in a one-night burst of energy.

On the eve of a flight birds seem to be aware of an unusual event. Magpies and crows are active, and owls and mopokes leave their shelters earlier than usual to feed on the moths. At first the moths hang limp and helpless, drying their wings in the twilight. Aborigines are never far behind. Hundreds of the moths are gathered into dillybags and, as soon as it is dark, large fires are lit into which the moths crash in great numbers, to be raked out and eaten by the eager diners.

Places where unusually large numbers of moths emerged together were remembered and given special place names. Thus the Murray River irrigation town of Waikerie preserves the memory of great feasts of *Trictena argentata* moths. They still emerge from the roots of the red gums and fly every year on the night of the first big autumn rain in early- or mid-April. Another species of Ghost Moth, *Trictena argyrosticha* Turner, flies at Stanthorpe, Queensland, also in April. It measures 6 inches across the expanded wings and is bluish-grey with a silvery-white flash across the forewings. Even larger species, of *Abantiades*, fly in Victoria and Western Australia.

World's heaviest insects

In addition to the Hepialidae, some of which bore directly into the stems of trees, there are the equally large wood-boring moths of the family Cossidae, sometimes called Goat Moths, from a fancied resemblance between the curled antennae of the male moths and the horns of a goat. Females of several species of Australian *Xyleutes* share the record of being the heaviest insects in the world, with wingspreads of up to 9 inches. The larva of a species which bores in the solid wood of *Eucalyptus* trees at Moolabulla, Western Australia, is illustrated. It fills the palm of an Aborigine's hand, providing a delicious meal: in fact, its taste, when it is lightly cooked in hot ashes, would delight a gourmet. I visited a cattle station at Mandora, in Western Australia, where a daily accompaniment to the whisky drink, before dinner, was a plate of toasted cossid grubs. They have a flavour all their own, like cream cheese with chitin adding the firmness of the crackling on roast pork. The grubs are equally delicious when eaten raw, but a word of warning. Bite off the rear end first, and discard the head, lest the biter's tongue be bitten by contractions of the powerful jaws of the expiring morsel!

This *Xyleutes* cossid grub, one of a species which bores into *Eucalyptus* trees at Moolabulla, Western Australia, is so big that it fills a man's hand. When it is lightly cooked in hot ashes its flavour would delight a gourmet.

Smaller-sized cossid grubs are eagerly sought. One common species feeds in the root of the Tumbleweed or Rolypoly Bush (*Salsola kali*). When the larvae are about to pupate they bite through the stem at ground-level and seal off the hollow root as a shelter, relying on the wind to roll the bush away before the insect is ready to emerge as a moth. Similar species of cossids feed on the roots of *Bassia, Zygophyllum* and other shrubs. The larvae of *Xyleutes amphiplecta* Turner serve both as food and as fishing bait for Aborigines of the Murray River in South Australia.

Bogong Moth hunts

Many people have heard of the Bogong Moth and its role as a native food. The adult moth (*Agrotis infusa*), one of the cutworm family, passes the summer sheltering in dark crevices and caves and under bark. Thousands congregate, in masses, in caves at high altitudes in the Australian Alps. Aboriginal men took excursions into these mountains. They made a mystery of the journeys, and there were restrictions on sex relations and on the presence of women. Great numbers of the moths were beaten into skin bags and compressed into cakes. Packages of the food were carried down to the families waiting below. Many of the details of the story of the Bogong Moth hunt have been left untold, but there are names on the map such as Bogong Heights, and the remains of temporary camping places, as high up as 6,000 feet on Mount Gingera, as witnesses to the eagerness with which this strange insect food was gathered from the crannies of the Australian Alps. Foxes now feed on this delicacy, once reserved for Aboriginal men and their families.

[The photos in this article are by the author.]

NATIONAL TRUST

The Curator of Molluscs at the Australian Museum, Dr D. F. McMichael, who represents the Museum on the Council of the National Trust of Australia (N.S.W.), has been elected to the executive of the Trust. He is also Chairman of the Montagu Island Committee and Vice-Chairman of the Conservation and Landscape Committee.

BOOK REVIEW

"LAND OF A THOUSAND ATOLLS". By I. Eibl-Eibesfeldt. Macgibbon & Kee Ltd. November, 1965. Price, $6.30.

The words "coral atolls" evoke thoughts of white coral sand, palms waving against sunsets, warm tropic nights: perhaps also of gay colourful little fishes, going about their business among coral turrets in blue-green water, lazy sea-cucumbers in warm shallows, and improbably large starfish among turtle grass. These things are not neglected in Dr Eibl-Eibesfeldt's account of a cruise in Hans Hass's three-masted yacht *Xarifa* through the Maldive Islands, Nicobars, and some Malayan islands. But his passion is the way animals, particularly fishes, behave. He gives intriguing accounts of why the Flute-mouth rides on the backs of other fishes; or the Sabre-toothed Blenny that mimics Cleaner Fishes, but bites pieces of flesh from its hopeful host; of fishes that use shrimps to dig their homes, and many other strange forms of marine animal behaviour.

It is clear that the one-year expedition on which this book is based was devoted to many things zoological and ethnological, but that sheer enjoyment was not forgotten. "This is really Paradise" shouts Dr Hass at one stage when the *Xarifa's* dinghy sails in to a beautiful coral island.

The book is packed with interesting underwater observation and anecdote, and the translator, Dr Vevers, of the London Zoological Society, has given us fresh, clear writing. The standard of illustration is high in both colour and black and white photographs and in line drawings.

Land of a Thousand Atolls can be strongly recommended for a naturalist's bookshelf, and will give many hours of pleasure.

ANZAAS CONGRESS

The thirty-ninth congress of the Australian and New Zealand Association for the Advancement of Science will be held at the University of Melbourne from 16th to 20th January, 1967.

The University of Melbourne will be host to the congress.

Extensive programmes have been drawn up for a wide range of scientific subjects. The programme for the zoology section, for example, will consist of symposia, some arranged by specialist societies, including the Genetics Society of Australia, the Australian Entomological Society and the Australian Marine Sciences Association; and others on topics drawn from the fields of cellular and comparative physiology, developmental biology, physiological ecology and parasitology. Joint symposia with other sections will be invited.

Full information about the congress is obtainable from the Organizing Secretary, Mr L. Mann, ANZAAS Congress Office, c/o. University of Melbourne, Parkville, N2, Victoria.

An artist's impression of a New Zealand Eagle, now extinct, attacking a moa bogged in the viscous lake deposit below the peat-crust surface of the Pyramid Valley swamp. [Drawing by R. J. Jacobs, from the Canterbury Museum booklet *Pyramid Valley*, 1949.]

Moas and Man in New Zealand

By J. C. YALDWYN

"To admit that species generally become rare before they become extinct—to feel no surprise at the rarity of the species, and yet to marvel greatly when the species ceases to exist, is much the same as to admit that sickness in the individual is the forerunner of death—to feel no surprise at sickness but when the sick man dies, to wonder and to suspect that he died of some unknown deed of violence."—Charles Darwin, "On the Origin of Species", 1859.

The origins and extinction of the New Zealand moa, giant flightless birds possibly ranging up to about 10 to 12 feet in height, are still subjects of considerable speculation to both biologists and archaeologists, amateur and professional alike. Such speculation was initiated by the great English anatomist Richard Owen, who in 1839 announced to the Zoological Society of London that a single broken thigh bone from New Zealand represented "a struthious bird nearly, if not quite, equal in size to the Ostrich". It continues to this day, when Dr Roger Duff, Director of the Canterbury Museum, Christchurch, documented, with extensive use of radio-carbon dating, "The Problem of Moa Extinction" in the stimulating Cawthron Memorial Lecture for 1963.

Zoologists are by no means agreed on the relationships of moas to other bird families. Dr R. A. Falla, of New Zealand, summarizes present day opinion by finding it convenient to classify them as struthious (literally "ostrich-like") birds, a composite group in which the ostrich of Africa, rheas

of South America, and the emus and cassowaries of Australia and New Guinea are included. These are sometimes alternately called ratite birds, a term which refers to their distinctive keel-less breast-bone, or sternum. In fact, as Falla points out, one of the few additional features they have in common is their size. There are one or two skull characters that show similarity, but this does not necessarily mean close relationship and could also be a convergent condition associated with habits and size. There is, indeed, good evidence for the polyphyletic origin of these large birds. That is to say, they may have been derived from different ancestral lines and their direct ancestors in any of these lines need not have been large birds. Gigantism is a phenomenon that has occurred at different times in earth history in several different groups of animals. It had its day among the reptiles long ago in the Mesozoic Era. It appears to have had its day among the birds at some more recent date and, in the southern hemisphere, where relict forms have tended to persist, some of the giant birds are still found and others, such as the dinornithiform moas of New Zealand, the elephant birds (*Aepyornis* and its allies) of Madagascar and the casuariiform *Dromornis* of Australia, are only recently extinct geologically speaking.

Arrival of Polynesians

In the case of the moas of New Zealand, it is now fairly certain, from accumulating evidence, that the time of final extinction was within the last 200 or 300 years. The question is, what brought about this change in the bird fauna of New Zealand? Was it due to the arrival of man in these relatively isolated islands, or was it due to changes in the environment quite independent of man?

Right: An almost complete skeleton of the moa *Euryapteryx gravis* partly exposed in the sandhills at Uruti Beach, Wairarapa, North Island of New Zealand. Dr R. A. Falla, shown in the photo, excavated the bones for the Dominion Museum, Wellington. [Photo: C. J. Lindsay, Dominion Museum.]

Below: The same skeleton mounted in a Dominion Museum display case. The bones are shown in the position in which they were found, the body lying on its front with the neck stretched out ahead and the leg bones extended behind. Note the bony tracheal rings (windpipe supports) lying below the neck vertebrae. [Photo: F. O'Leary, Dominion Museum.]

The simplest explanation, as the New Zealand palaeontologist Dr C. A. Fleming puts it, is to attribute all late Holocene (i.e., geologically *recent*) extinction of the extensive range of large birds in this area to the profound ecological changes brought about by the arrival of Polynesian man with fire, rats and dogs—a combination including the first three aggressive mammals to arrive in these oceanic islands. The incomplete evidence available is not inconsistent with this conclusion.

Change in bird fauna

When one thinks of recent changes in the bird fauna of New Zealand, one tends to think merely of extinction of forms rather than of addition to the number of forms already there. However, the wide view of this faunal change, in geologically recent times at least, can be considered in terms of three phases.

Phase I is the extinction of some twenty-seven species of moa, currently placed in six genera, and some fifteen species of other birds, including rails, waterfowl, birds of prey, snipe and crow, many of them giant and flightless forms, in a comparatively short space of time apparently coinciding with the arrival of Polynesians in New Zealand.

Phase II is the extinction and near extinction of some ten species of birds and the great reduction of many other species in the fifty-odd years following the arrival of Europeans in New Zealand. Included here are rails, quail, snipe, parrots, an owl and several perching birds such as New Zealand wrens (*Xenicus*), New Zealand thrushes (*Turnagra*) and New Zealand wattle-birds (including the well-known Huia, *Heterolocha*).

Phase III is the successful introduction of some thirty-six species of alien birds into New Zealand with, of course, the attempted introduction of at least eighty more, a process which started about 1860 and is being carried on to this very day. Successful introductions include waterfowl, quail and pheasant, pigeon, feral Australian parrots, kookaburra, lark, Old World thrush and blackbirds, at least six European finches, sparrows, Indian myna, the rook and two Australian magpies.

These so-called phases are by no means exclusive, and, in fact, overlap from the point of view of time in the case of II and III. They do not take into account the many examples of self-introduction, or recent "natural spread", of Australian birds such as the White-faced Heron, the Spur-winged Plover, the Coot, the Grey-breasted Silvereye (*Zosterops lateralis*) and many others which are only in the process of being recognized in New Zealand as recently established and self-introduced forms.

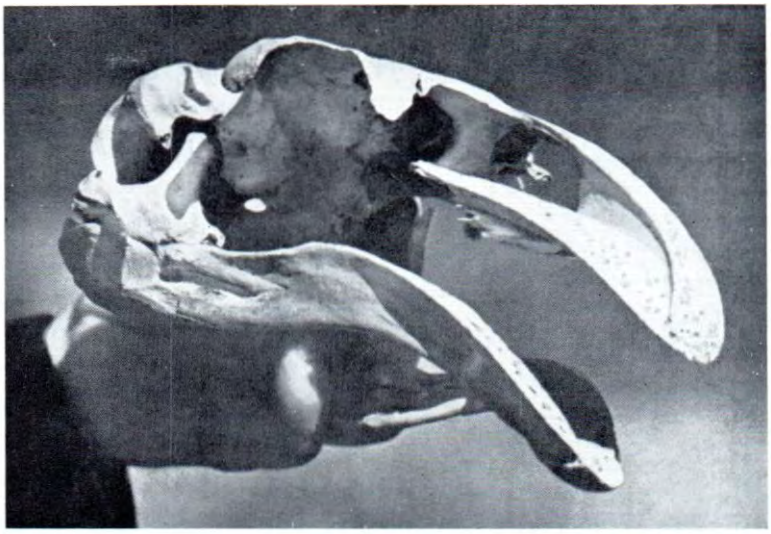
It is the first of these phases which concerns us here. The extinction of these giant birds, and the relationship of this extinction to the arrival of Polynesians in New Zealand, can be illustrated very realistically by a consideration of some actual natural and archaeological sites where discoveries of moas and other birds have been made.

Pyramid Valley swamp

So called from the eroded limestone pyramids which border the eastern margin of the swamp, Pyramid Valley lies in north Canterbury near Waikari, approximately fifty miles north-west of Christchurch. This most famous of New Zealand moa-bone swamp deposits was discovered as late as 1937 by a farmer while burying one of his dead horses and has been excavated by the Canterbury Museum from 1939 on and off right to the present day. From some three acres of moist, yellow lake deposit below a two-foot skin of black swamp peat, a total of about 150 nearly complete moa skeletons have been found to date and it has been calculated that the concentration of moas bogged and mired during the past history of the swamp is about 800 to the acre.

The unique feature of the Pyramid Valley swamp, and the point that makes it more important than any of the score or so other moa swamps discovered throughout the country, is that the moas are found as individual skeletons and *not* all mixed together and disarticulated—a condition which has caused so much anatomical and systematic confusion in the past.

The 150 moas found belong to four different types. Half were relatively small moas called *Emeus crassus*, standing about 4½ to 5½ feet high, while the remainder were divided between another smallish moa of



The massive beak and mandible of the giant moa *Dinornis maximus* were well adapted to the incessant grazing and browsing necessary to support this huge bird. *Dinornis* stood higher than any mammal now living except the giraffe and the African elephant, and probably required as much grass per day as a bullock. [Photo: from the Canterbury Museum booklet *Pyramid Valley*, 1949.]

about the same size called *Euryapteryx gravis*, a larger moa standing about 6 to 7 feet called *Pachyornis elephantopus*, and the largest of all moas, *Dinornis maximus*, standing about 10 to 12 feet high.

In addition to this assemblage of moas, the swamp deposit contained bones of quite a large fauna of other birds, including such present-day forms as the kiwi, ducks, hawks, parrots, and rails such as the weka (*Gallirallus*) and takahe (*Notornis*). Extinct forms from the deposit included the Giant Rail *Aptornis*, standing about 3 feet high; the extinct goose *Cnemiornis*, about the same size; the extinct New Zealand Eagle *Harpagornis*, with a wing-span of about 7½ feet (shown here in a reconstructed drawing attacking a bogged moa in the swamp); the extinct Finsch's Duck, believed to have been flightless, and the extinct New Zealand Crow. All these birds, as well as the moas, had been trapped by one means or another in the treacherous surface of the swamp and their bones preserved in the sticky layers beneath.

Several attempts have been made to get an *absolute date* for the swamp by the radiocarbon method, but these have been complicated by the quantity of "radioactively dead" carbonate from the local limestone dissolved in the swamp waters. However, it appears that the surface may have been trapping moas and other birds up until the 14th century A.D. and that it had been trapping them over a long period of many hundreds of years.

Sink-hole trap

A contrasting example of a moa-bone deposit is the Martinborough Cave site in the limestone hills of the Wairarapa area in the southern North Island of New Zealand. This "cave", in fact a vertical sink-hole, was discovered by a deerstalker in 1914. He found moa bones at the bottom of the 30-foot shaft and reported his find to the Dominion Museum. After the Great War the Museum sent a party to the cave, and using a simple tripod hoist over the hole, they were able to bring big collections of well-preserved bones back for study.

Unlike Pyramid Valley the bones from the Martinborough Cave were all completely disarticulated from their original skeletons and jumbled together in the clay filling of the sink-hole floor. Moas of three different types were present, but possibly several species of each type are represented. The large *Dinornis* was found in three size ranges (believed to be three species); *Pachyornis* is represented by two species both smaller than the Pyramid Valley form, and another medium-sized moa type, *Anomalopteryx* (not known from Pyramid Valley), is represented by what is believed to be a further three species differing in size range.

In addition to these possible eight species of moa (together a total of several dozen individual birds), the small sink-hole shaft deposit contained bones of kiwi, New Zealand wattle-bird (*Callaeas*), small perching birds, the extinct North Island large form of *Notornis*, at least twenty-two giant *Aptornis* rails, an unbelievable collection of scores of kakapo (large, flightless ground parrot, now extinct in the North Island and very rare in the South Island) and finally numerous extinct Finsch's Duck.

This sink-hole is situated at about 2,500 feet above sea-level, on the crest of a ridge leading down from the tops towards the valley, and would thus act over a long period of time as a natural pit-trap across the paths of any flightless birds moving up or down the ridge, to or from the valley. The continuing efficiency as a pit-trap to the present day is shown by the accumulation of sheep, pig and hedgehog bones (all European introductions) found loosely overlying the moa deposit. The age of the bone-bearing clay filling of the sink-hole is uncertain, but it is not covered by the solifluxion debris of the last glaciation known from the area, and is thus less than 11,000 years old on geological evidence alone. It is probably considerably younger than this, but a radiocarbon date from the bones themselves is impossible due to lime carbonate contamination.

Pyramid Valley and Martinborough Cave give a picture of the past bird fauna at a period before man arrived in New Zealand, or, if not before his arrival, at least at a period early in phase I as outlined above, when his influence on the fauna had not made itself felt in the vicinity of these sites.

Moa-hunting Maoris

Turning now from swamp and limestone cave sites some consideration must be given to both natural and archaeological sites in coastal sand-dunes and river mouth silts and gravels. Such accumulations of moa bones are very common in New Zealand and can occur as individual, isolated skeletons more or less in the position of articulation, as shown in the photographs of the Uruti Beach *Euryapteryx gravis* find reproduced here, or as masses of fire-blackened and broken bones eroding from a human kitchen midden. Oven pits and midden refuse accumulations from the earliest part of the Polynesian occupation of New Zealand contain cooked or worked moa leg bones so commonly that this period has been loosely termed the "Moa-hunter period of Maori culture".

Up until the last few years it was assumed from the archaeological evidence available that the only moa types met with by man were *Euryapteryx*, known in abundance from South Island coastal middens, and, to a lesser extent, *Emeus*. The accepted theory was that before the arrival of man the other genera, such as *Dinornis*, *Pachyornis*, *Anomalopteryx* and the small South Island *Megalapteryx*, had already become extinct, due either to climatic change or to the effect of insularity on an originally continental fauna, or possibly to the arrival at the end of an evolutionary trend line.

In the last few years, however, careful archaeological excavations in various parts of the country have demonstrated that man hunted and ate representatives of the whole range of moa genera from the biggest to the smallest. Also, it has been shown that the moa-hunting Maori killed and used as well the Giant Rail, the great extinct goose *Cnemiornis*, the extinct eagle, the extinct swan and the extinct crow.

Moas after Tasman's voyage

Some idea of the rapidity of the phase I extinctions in New Zealand, as well as the lateness of their termination, can be gained from the work of Mr L. Lockerbie, of the Otago Museum. He has been able to demonstrate from several different southern river-mouth campsites—all securely radiocarbon dated—that not only was *Dinornis* itself extensively hunted as well as *Euryapteryx* at his earliest dated layers (about 1100 A.D.), but it was still being hunted throughout the 13th to 16th centuries, and right up to the end of the 17th century. This hitherto unbelievably late date for the giant *Dinornis* was obtained at the Tautuku archaeological site, where associated leg bones of *D. torosus* (not as large as *D. maximus*, of Pyramid Valley, but still a very large bird) have been dated to about the

Left leg of the moa *Pachyornis mappini* in articulation as excavated in a Maori oven or *umu* at the Ohawe Beach archaeological midden site, near Hawera, New Zealand. The slender fibula bone is in an abnormal position alongside the femur, and was possibly disturbed after excavation. Note the rounded stones of the typical Maori oven. [Photo: L. E. Thomas in association with A. G. Buist.]

year 1670 A.D.*, that is, some thirty years after Abel Tasman discovered New Zealand. Lockerbie's work also shows that shortly after this date, about 1700, the moa-hunters' large river-mouth campsites, highly suitable for a moa economy, were abandoned and part of the population shifted to primary fishing-sites and part probably went inland to hunt the remaining moa. As the generally agreed date for the beginning of human occupation of New Zealand is the period between 500 and 1000 A.D., this gives a time span of about seven to twelve centuries for the first phase of the recent changes in the bird fauna of New Zealand.

The point to come out of all the dates and details given above is that, contrary to popular theory of a few years ago, it now appears that the large moas and other giant flightless birds of various kinds did not become extinct from what might be called natural phenomena, with the moa-hunting Maori taking a few small moas of an already nearly extinct stock. Instead, it appears that Polynesian man arrived in New Zealand some time before 1100 A.D. and through his own efforts, and through the effect his presence and the presence of his dog and associated rat had on the natural undisturbed environment, caused the decline and extinction of the whole thriving array of oversized, probably unadaptable, largely flightless birds —moas, rails, eagles, ducks, geese, swans and crows. That was the end of what was termed above phase I; phases II and III, the European extinctions and introductions, are known only too well—they are actively going on across the Tasman today.

Note: Reference must be made here to the published work on this subject by the New Zealand biologists and anthropologists Dr R. Duff, Dr R. A. Falla, Dr C. A. Fleming, Mr L. Lockerbie and Mr G. R. Williams. Their ideas, and often their words, have been used extensively in the preparation of the above article, though the author takes complete responsibility for the conclusions given here. Without their individual work in this field, general articles such as this could not be written. It must be emphasized that the range of statistical error given with the original radio-carbon dates has been omitted in every case in the text above.

* The N.Z. Institute of Nuclear Sciences now reports that radio-carbon measurements from moa bone carbonate give dates which are too recent.

DESERT SNAILS

By DONALD F. McMICHAEL

IT sounds almost impossible, doesn't it? Desert snails! Everyone knows that snails are wet, slimy creatures which abound on suburban lawns during and after rain in the warmer months, and which play havoc with the seedlings.

It is of course quite true that land snails are creatures whose very existence is dependent upon moisture, for they have evolved from marine ancestors and during this evolution they have not developed any skin impermeable to water such as is characteristic of the terrestrial vertebrates or a cuticle like the insects'. The skin of a snail is soft and thin, and water passes through it like blotting paper. Nonetheless the snail has a protection for this delicate skin in the form of the shell, which in most cases is impermeable to water. Once withdrawn into the shell the snail is well protected against desiccation, but there is still a danger of water loss through the opening of the shell. Unfortunately, the evolution of the land snails was accompanied by the loss of the operculum, the small shelly or horny trapdoor which most marine snails have attached to the back of their foot, and with which they close up the aperture of the shell when they withdraw inside it. So the land snails are vulnerable at this point.

Tallaputta Gorge, west of Haast's Bluff, which is west of Alice Springs, is a refuge for moisture-loving animals in the dry interior. [Photo: Author.]

Importance of adaptability

One of the keys to success in the world of nature, however, is the possession of a quality known as adaptability. Those animal groups which are adaptable can respond to changes in their environment by patterns of behaviour which help to circumvent the effects of the changes, and thus are more likely to succeed and survive. Fortunately for the land snails they are an adaptable group and have not been unduly handicapped by the lack of an operculum. Instead, they have developed a new structure which takes its place, known as the epiphragm. In its simplest form, this is just a thin layer of hardened mucus, mixed with calcareous particles, which is exuded from the collar of the snail as it withdraws into its shell. This seals the aperture, either by sticking the shell to the substrate on which it is sitting, or by forming a thin sealing layer across the mouth of the shell. Those snails which normally live in fairly moist climates, such as the common introduced garden snail, *Helix aspersa*, need no more than this to see them through dry spells.

Those shells which live in drier climates have thicker epiphragms as a rule, so that in many species the animal is sealed in its shell by a solid door, impermeable to water vapour but apparently not to air, which is almost identical in shape and function with the operculum. Examples of such well developed epiphragms are common in Australian snails, because such a large part of the continent is dry, and even though not

Bothriembryon barretti with the epiphragm in position (bottom left), with the animal beginning to emerge (top left), and with the discarded epiphragm beside it (right). Approximately natural size. [Photo: Thelma Hartley, by courtesy of the Malacological Society of Australia.]

a true desert, much of it is subject to long periods without rain during which the species must be able to survive. There are a number of species in Australia which inhabit the most arid regions of the centre and in some of these the epiphragm can be as much as a millimetre thick, or there may be several successive layers between the animal and the outside. As soon as wet conditions return, the epiphragm is discarded as the snail emerges (unlike the operculum of the marine snails, which is firmly attached by muscles to its owner). A few years ago an observer watched the snail *Bothriembryon barretti*, which lives under bushes on the Nullarbor Plain, emerge from a period of aestivation and was able to photograph the process during which the epiphragm was cast off. She described the scene at which the snails were found: "operculum-like objects of thin, white, calcareous structure [were] literally covering the ground for about 3 feet underneath nearly every bush."

Long-term survival

The problem of survival in desert or arid areas is intimately bound up with the need to conserve water. Once withdrawn inside the shell and sealed up with an epiphragm, evaporation from the body is cut to a minimum and the animal can live for many weeks, months, or in some cases years, in a state of suspended animation, during which body processes are reduced to an extraordinary degree and the animal's nutrition is provided by fats and carbohydrates stored in its tissues. The Australian record for long-term survival seems to be the land snail *Chloritisanax banneri* from north Queensland, which lived in a cardboard box in the Australian Museum for almost 6 years. However, this individual may not have been continually aestivating, for it had eaten much of the soft cardboard from the inside of the box, although it had survived without water. Species from other parts of the world have also been recorded as living for up to 6 years without food or water, and there is even one record of a snail which appeared alive some 23 years after it was collected from a dry part of Brazil.

Evidence of the aestivation of Australian snails in nature, and their response to rain, is often quite dramatic. In the drier parts of the continent during dry spells, it is

Land snails of the genus *Sinumelon* litter the ground in this dry country near Erliwunyawunya Rockhole, Musgrave Ranges, northern South Australia. [Photo: Howard Hughes.]

Pleuroxia adcockiana, a native snail found living among *Lindsaea ensifolia* ferns at Tallaputta Gorge. [Photo: Author.]

almost impossible to find any trace of living snails. Yet after a fall of rain, with almost unbelievable rapidity snails may emerge by the thousand, and we must assume that they have been hidden away in crevices in rocks and deep in the soil, or among the roots of trees and grasses. Even the Australian Native Slug (*Triboniophorus graeffi*) is known to be able to survive long periods without rain, and to appear suddenly when rain falls, as happened at Mount Kaputar, in north-western New South Wales, in 1950.

Survival of eggs

It is probable that some snails survive through dry periods, not as aestivating adults, but as eggs. Although snail eggs do not usually have a shell and are not especially resistant to desiccation, they are usually laid buried in soil. Studies on some native Australian species suggested that the eggs which normally hatch after 8 weeks, would not do so if weather conditions were unfavourable, but could do so at any time up to 4 months if the weather improved. In the case of snails which survive as adults, it is probable that they compress their normal breeding activities into a very short time-span immediately following rain and that development of the eggs and growth of the young are rapid while good conditions last. When heat and dry conditions return, snails are often caught in unfavourable situations and perish in exposed places. Evidence of this is widespread in central Australia where in places the ground is littered with the bleached shells of snails which presumably were unable to find shelter before succumbing to the desert's heat.

Some snails which live in dry places do not make especially thick epiphragms, but instead live in microhabitats which provide relatively moist conditions, even though surrounded by aridity. For example, the land snail *Sinumelon perinflatum* lives in Palm Valley and elsewhere in the ranges west of Alice Springs. Although the country round about is very dry, it can usually be found commonly at the very bottom of the many layers of fallen leaves which surround

Adiantum hispidulum (left) and *Lindsaea ensifolia*, two species of ferns growing in Tallaputta Gorge beside a permanent waterhole. [Photo: Allen Keast.]

A permanent waterhole at the entrance to Cycad Gorge, Palm Valley, Northern Territory, in April, 1965. This is a typical habitat of various shelled crustaceans and freshwater snails of the genera *Physastra* and *Lymnaea*. [Photo: H. J. de S. Disney.]

the bases of the *Livistona* palms and under the piles of litter beneath large *Melaleuca* bushes, usually right on the soil surface where traces of moisture and relatively cool temperatures persist for long periods. Other snails inhabiting the inland of Australia do so, not by being adapted to dry conditions, but by surviving in refuges where reasonably moist conditions normal for snail life exist. Such a locality is Tallaputta Gorge, west of Haast's Bluff, in central Australia. At the head of the gorge is a small, permanent spring, where mosses and ferns grow deep in a cleft between the rock walls, and snails of the genus *Pleuroxia* were found living among the roots of the *Lindsaea* ferns. Presumably during wet weather these species would range farther abroad, but retreat to their mossy refuges when conditions became drier.

Freshwater snails

Apart from the land snails, there are a number of freshwater snails which inhabit the arid inland of Australia. In any permanent waterhole several species of snails may be found. Others appear in temporary waterholes and rivers after months of dryness and again it is presumed that these have emerged from hiding places deep in the mud and similar sheltered situations. Freshwater bivalve shells such as mussels are also well-known inhabitants of temporary rivers and ponds in the inland. The common species in Australia's Centre is *Velesunio wilsoni* and it was undoubtedly this species which was reported many years ago as being dug out alive from 4 to 5 feet below the bottom of Cooper's Creek by Aborigines, about 8 months after the water had disappeared.

THE AUSTRALIAN INSTITUTE OF ABORIGINAL STUDIES

By FREDERICK D. McCARTHY
Australian Institute of Aboriginal Studies, Canberra, A.C.T.

OUR real knowledge today of the Australian Aborigines and their customs is represented by a few shelves of books and monographs and by many articles and papers scattered through scientific journals. The recording of this information began with Dampier in 1729, Captain Cook in 1770, and the First Fleet chroniclers in the 1790's, and, as Professor Elkin has pointed out, it passed through phases of incidental records from 1788 to the 1870's and of compilation and collection until the end of the 19th century, when more important individual field projects were undertaken until in 1925 organized systematic research began. Each of these phases produced important contributions, and an ever-increasing number of individuals and institutions participated in this research as time went by. But the development of a greater interest in the culture of the Aborigines in the greater part of the 19th century was prevented by the hostilities between the settlers and the Aborigines, which wiped out the latter in many areas and in others left behind a stateless remnant. Thus it is not surprising that the only record of some tribes is their name, of others a short list of words or a description of weapons or hunting practices. Some tribal groups were extinct before they could be studied, there was an understandable lack of interest in Aboriginal customs for some time after hostilities ceased in an area, and not enough people in contact with Aborigines took a real interest in their customs. Nevertheless, some monumental contributions were made by explorers, Government officers, settlers, missionaries and laymen.

Anthropology is a young science, and from its establishment at the University of Sydney in 1925, planned research began in various parts of the continent. The universities in Adelaide, Canberra, Perth, Melbourne and Brisbane have added to the flow of fieldworkers, some of whom came from Great Britain, Europe and America. Much of the research was financed by Rockefeller Foundation and other grants administered by the Australian National Research Council, which was absorbed by the Australian Academy of Science in 1954. As available research funds decreased and the anthropologists struggled to fill the gaps in our knowledge of Aboriginal culture, the administrations and missions steadily concentrated the Aborigines on their settlements, where educational and other civilizing processes gradually broke down their traditional life. Great gaps were torn in the fabric of Aboriginal culture by the discontinuance of ceremonies, with their rich mythology, art and music, because the Aborigines are an intensely religious people whose philosophy of life is centred on the perpetuation of their beliefs and rites. The decrease in their numbers has left none or few living informants on the customs of many tribal groups. There was thus an urgent need for a national effort to be made if all materials available on Aboriginal culture were not to be lost.

Establishment of the institute

In 1960, Mr W. C. Wentworth, M.H.R., submitted a plan to the Commonwealth Government for such a national programme of research to be effected. It was considered by a Cabinet sub-committee, and then by a working committee of the Australian National University. A conference of over sixty anthropologists, sociologists, geographers and others interested in the subject was held in Canberra in May, 1961, to discuss the information known about the Aborigines, the gaps in this knowledge and suggestions for future research. The Commonwealth Government then set up an interim council of sixteen which met in December, 1961, and decided on the title of the Australian Institute of Aboriginal Studies for the organization. In June, 1964,

an Act was passed to establish the Institute as a statutory body under the Minister in Charge of Commonwealth Activities in Education and Research.

The Institute, which is located in Canberra, is now governed by a Council of twenty-two and administered by a staff which includes a librarian, bibliographers and sound technicians. The eighty-nine members are people normally resident in Australia who are eminent either by reason of their knowledge of, research in, or services to, Aboriginal studies. A number of Corresponding Members resident abroad, and Associate Members resident in Australia, have been appointed.

The functions of the Institute are to promote and publish research on the Australian Aborigines, to encourage co-operation between institutions concerned with this field of research, and to assist these institutions in the training of research workers. The Institute thus sponsors and finances research work but does not employ its own professional staff for this purpose.

Research projects

Since its inception in 1961, the Institute has sponsored almost ninety research projects in all fields of Australian anthropology, as follows:—

Subjects: social anthropology, 11; demography, 2; linguistics, 23; music, 5; dance choreography, 1; human biology, 9; archaeology, 17; rock art, 6; portable art, 3; archival, 3; personal assistance, 5.

States: Western Australia, 14; Northern Territory, 20; Central Australia, 1; South Australia, 7; Victoria, 2; New South Wales, 11; Queensland, 18; Tasmania, 2; Europe, 2.

These were all independent studies made in many parts of the continent, the majority being in the Northern Territory, Queensland and Western Australia, where the greatest opportunities for research exist. The archaeologists, most of whom are centred in eastern Australia, carried out most of their work in this region but they are now seeking sites elsewhere on the continent. The linguists have a rich field to exploit in every State.

The range of this research and of its contribution to our knowledge of the Aborigines—of the people, their culture, art and pre-history—may be illustrated by mentioning some of the projects, which include Dr Munn's study of the art and symbolism of the Walbiri and Bidjandjara tribes in the Northern Territory; Mr R. Dixon's study of nine languages of the rain-forest tribes in north-east Queensland, from which he concluded that their languages are Australian in type and not Tasmanoid; Mrs L. Hercus's recording of linguistic material from nine languages in Victoria thought to be extinct; Dr B. Yamaguchi's study of the comparative osteology of the Australian Aborigines and the Ainu of Japan; Mr T. G. H. Strehlow's research on some of the totemic rites of Aranda of central Australia never before witnessed by a white man; photographic and recording surveys of rock engravings and paintings in north-west Australia, South Australia (Flinders Ranges), western Arnhem Land and Northern Territory, Cape York and Sydney-Hawkesbury area; Mr W. J. E. Webster's study of the application of infra-red and ultraviolet photography in archaeology and rock art; studies by Mr R. Marchant and Mr B. Plomley of material in French archives on the Australian and Tasmanian Aborigines; excavation in New South Wales, Queensland, South Australia, Western Australia and Tasmania by various archaeologists, including the first research of its kind by a professional archaeologist in Tasmania.

While the research programme of the Institute includes all disciplines of anthropology it is to a considerable degree dependent upon the availability of specialists and the relative amount of research done in each field.

The linguistic programme is an interesting example. Dr A. Capell's survey of Aboriginal languages in 1963 for the Institute revealed that in a total of 633 some 73 are presumed extinct, there is no information on 31, 375 are in danger of disappearing while basic information on 131 and depth studies on 23 are required. As there are only one or a few speakers still living of some languages, the seriousness of the problem may be realized. To cope with the tremendous research problem involved the Institute is financing the appointment of a number of

research fellows and post-graduate scholars, and independent studies by other research workers and the Summer Institute of Linguistics. Over sixty languages have been studied during the past two years.

Mythology

Aboriginal mythology and ceremonies form another major research programme of the Institute. An immense amount of mythology, music and song cycles yet remain to be recorded in Queensland, Northern Territory, Arnhem Land and Western Australia, studies of which are being made by ethnomusicologists, linguists and social anthropologists. An important part of this general project is the filming of ceremonies and study of the relevant mythology. We have filmed the Ubar gong ceremony on Goulburn Island, an emu clan mourning ceremony called Djalambu at Milingimbi, the Yabudurawa historical ceremony on the Roper River, a big series of clan dances at Aurukun, and portion of the Lockhart River Bora initiation ceremony, in Cape York. When an adequate series of the many other ceremonies still performed have been filmed, it will be possible to make detailed descriptive and comparative analyses of the dances, music, songs, art and mythology. Other films illustrate the daily life of the Bindubi in the Western Desert, the making of stone spearpoints in the Kimberleys, of weapons and crafts at Yuendumu in the Northern Territory, and others are planned. Many of these films will have to be made during the next few years before the ceremonies are discontinued and the Aborigines pass completely over the line from traditional to a European economy. One gratifying effect of the filming programme has been the realization by the Aborigines of the value of the film as a permanent record of their ritual life and to illustrate the customs of the past for future generations of their own people.

Investigation of prehistory

An immense field of research awaits implementation on the physical anthropology, physiology, biology and psychology of the Aborigines, for which the Institute's support is being increasingly sought. Negotiations are now in progress to develop cooperation between the Institute and the International Biology Programme to sponsor widespread field research in human adaptability as applied to the Aborigines.

The exploration of Australia's prehistory has been pushed ahead rapidly in the past decade. Occupation deposits, left by the Aborigines in rock-shelters and other places, which have been shown to be up to 18,000 or more years old, have been excavated in eastern and northern Australia, and more ancient alluvial deposits are being investigated for traces of man. Some of the fundamental problems of Australian prehistory—how long has man been on the mainland and in Tasmania, did the physical characteristics of man change during this period, the prehistoric culture sequences in various parts of the continent, when did the dingo arrive and to what degree did Aboriginal technology advance from prehistoric to recent times—are being studied intensively in the field and laboratory with the support of the Institute.

Other aspects of Aboriginal studies being advanced by the Institute are those of rock art and material culture. The natural deterioration of galleries of rock paintings and engravings, in addition to the unique and remarkable quality of the art in many areas, has prompted the Institute to sponsor photographic and scale recordings of the art with a view to the publication of albums of some of the finest work. The study is particularly urgent of the mythology and meaning of the art in galleries where Aborigines can still supply this information. Similarly, the areas in which the material culture of the Aborigines may still be collected are shrinking every year, and the Institute is anxious to obtain as fully representative as possible a collection for display in Canberra. Thus the Institute has initiated a joint collecting programme with the Administration in the Northern Territory. Collections of ritual objects are obtained when ceremonies are filmed, and the gaps in the Commonwealth collection are gradually being filled.

Above has been given an outline of the principal lines of research in Aboriginal studies being followed by the Institute. As an aid to research workers, institutions and others interested in these studies, the Institute is developing various facilities. For example, its library now consists of over

3,000 volumes, papers and manuscripts. Its bibliography now comprises almost 10,000 fully annotated author-entries and some 103,000 cards in the six sections into which it is organized. A catalogue of sixteen categories of Aboriginal relics in situ —rock paintings and engravings, stone arrangements, quarries and campsites, ceremonial grounds, carved trees and others— all over Australia is now being compiled as a record and guide to the immense number of these antiquities, whose protection and preservation are a complementary problem, in this country. Questionnaires have revealed which museums in the world possess collections of Aboriginal material culture, including the many important collections made for or sold to foreign museums in early times. In the Sound and Film Section of the Institute is an archive which now contains over 600 hours of tape recordings of language and music, and scientific films (not for loan), of Aboriginal life. This section issues tape recorders, cameras and other equipment to fieldworkers.

Finally, there should be mentioned the publication of major studies in the Institute's Occasional Papers, of information helpful to fieldworkers in its manuals, and of current news in its Newsletter. Recordings of Aboriginal music have also been issued.

BOOK REVIEW

"FURRED ANIMALS OF AUSTRALIA", Ellis Troughton; eighth edition; Angus and Robertson; i-xxxii, 376 pp., pls I-XXV; 1956; price, $5.

This book has been the standard popular account of the mammals of Australia for the last twenty-five years. Its value is amply testified by the publication of the eighth edition and it still retains considerable popularity in spite of its age.

The only comparable works on Australian mammals, Wood-Jones' *Mammals of South Australia* and Le Souef and Burrell's *Wild Animals of Australasia*, are either restricted in their coverage or no longer available. *Furred Animals of Australia* is thus likely to remain the main handbook on mammals for the popular reader for several years to come.

The main changes that are involved in the latest edition are a re-appraisal of the systematics of certain small insectivorous marsupials of the genera *Antechinus* and *Sminthopsis* and also of the rodent genus *Notomys*. Other minor alterations in the distribution and biology of some species have also been included.

The main format of the book is identical with that of earlier editions. This raises the point of one of the major objections to its lay-out, since lack of adequate headings makes it extremely difficult to locate precise details of information easily.

Adequate descriptions of the animals are not normally given, nor are basic dimensions included, although both these features would be of considerable value. The majority of faunal works now include biological keys which are most useful in determining the identity of a particular species. It is most regrettable that keys are completely lacking in this present work.

Although Neville Cayley's illustrations of birds are reasonably pleasing, his coloured pictures of mammals in this volume leave much to be desired. It is virtually impossible to identify any but the larger and more distinctive mammals from the plates. Colour photographs can now be reproduced reasonably cheaply and their inclusion would improve the value and appearance of the book considerably. Mammal workers in Australia are now beginning to collect adequate series of coloured slides which could be used as illustrations.

It is to be regretted that this book has not really moved with the times. Intensive research on many aspects of mammal biology is now being carried out in Australia, but little of this work has been incorporated in this book. This modern research includes revised classifications of marsupials, and considerable work on the ecology and physiology of many native mammals. In spite of this, the accounts of reproduction and birth in marsupials still smack of those given by Wood-Jones in 1924 and no explanation of the anomalies of the gestation period in red kangaroos, which have been shown by Sharman to be due to delayed implantation, is given.

The general style of the book is pleasant and makes entertaining reading, but there is a tendency towards sentimentality about certain animals, and some aspects of behaviour are explained in anthropomorphic terms. Structural adaptations are often described in a teleologically Lamarckian manner.

Furred Animals of Australia is the only readily available work which gives a general account of the whole of the mammal fauna of the continent. It is to be regretted that it does not cover New Guinea, which has a basically identical mammal fauna. It is certain that past editions have rendered sterling service in stimulating the interest and curiosity of the average Australian in the remarkable mammals which are found here, and it is likely that it will continue to do so for some time to come.

It is to be hoped that in the future, gradual improvement will occur by the introduction of good colour photographs, maps and keys, which are much needed to modernize this work.—*Basil Marlow*.

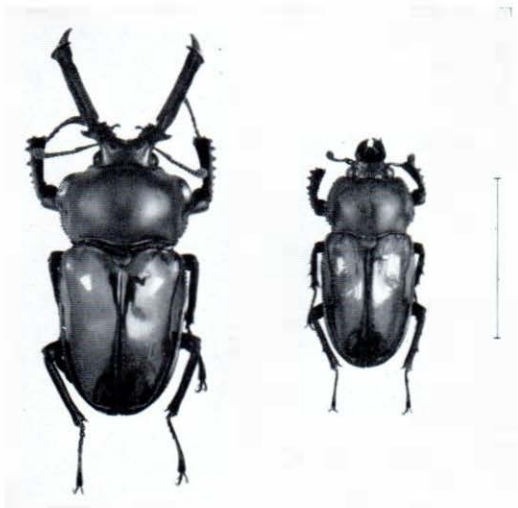
STAG BEETLES

By B. P. MOORE

CSIRO, Division of Entomology

THE well named stag beetles (family Lucanidae), with their extraordinary, antler-like mandibles, have excited the interest of naturalists for many generations, and early works of reference frequently included highly speculative drawings depicting rival male beetles locked in mortal combat. However, although such contests may occur in nature with a few species, they are largely matters of display and seldom result in injury of any kind. Indeed, the massive mandibles of many male stag beetles are virtually functionless—and as those of us who have handled the living beetles are only too well aware, it is the female, with her short pincer-like jaws, that can inflict the really painful nip.

With few exceptions, notably in our own fauna, stag beetles are normally dressed in sombre hues, with black predominating. Their integument is extremely hard and tough and they are more remarkable for their bizarre and often extravagant development than for grace and beauty. However, anyone seeing, for the first time, a well arranged and representative collection can hardly fail to be impressed by the diversity of form displayed, and may well be moved to ponder upon possible reasons for the development of such cumbersome appendages as many species possess.



The male (left) and female of the red and bronzy-green *Phalacrognathus muelleri*, of northern Queensland, Australia's finest stag beetle. The scale line equals 1 inch.

Polymorphism

The regular occurrence of markedly different forms of individuals within a single species is termed "polymorphism" and is a phenomenon of special interest to students of evolution. The stag beetles afford a classical example. Here, the sexes are almost always very different in outward form and the males are also very variable amongst themselves. With some species, two distinct forms or "phases" of the male exist side by side, with only the very occasional intermediate example to reveal the true relationship. Inevitably, in such cases, the older naturalists, with only limited material before them, were misled into describing several species where there was only one. On the other hand, males of many species show more or less continuous variation in size and development, from very small individuals, with short stout mandibles approximating to the female pattern, to large individuals with very large, often gigantic, mandibles, with dentition utterly unlike that of their lesser relatives. This disproportionate or "allometric" growth is characteristic of many groups of animals, where secondary male sexual characters are well marked. The tusks of the elephant, the antlers of deer and the wattles of the turkey are examples that immediately spring to mind. Extreme development in all these cases is probably merely an expression of male vigour, perhaps a by-product, with no great evolutionary significance, of high hormone concentrations during the formative stages of development. At all events, it is certainly difficult to believe that the male stag beetle, burdened with enormous, immovable jaws that barely clear the ground,

could have acquired such grotesque appendages as a direct result of the struggle for survival.

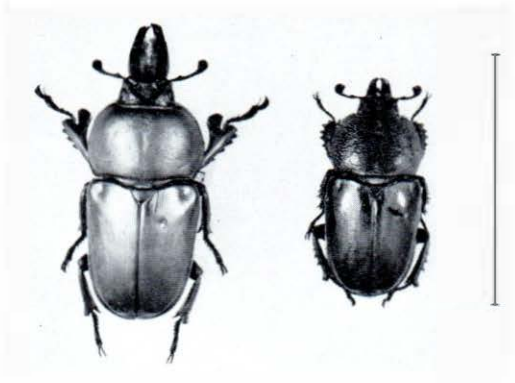
The Australian species

Our stag beetles number some seventy-five species—a little under one-tenth of the known world fauna—and they include several exceptionally beautiful forms. The brilliant, golden-green *Lamprima* species are well-known beetles that sometimes swarm, locally, in early summer, in both eastern and western States. They are most frequently seen about young banksias or "whipstick" gums, where they congregate for mating purposes. They often appear in suburban gardens, where their jewel-like colouring adds an element of interest, but they do no harm. Their close relative, the gloriously burnished, red and bronzy-green *Phalacrognathus muelleri,* of northern Queensland, can fairly claim to rank with the finest of our native beetles. Always uncommon, this magnificent species now seems to be declining, owing to the activities of the timber-getters in its forest home, and few, if any, present-generation entomologists have been fortunate enough to see it alive.

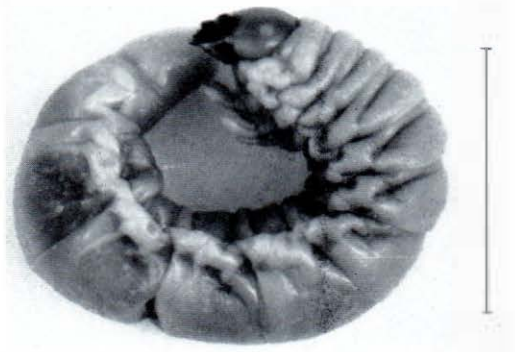
These brilliantly coloured species, together with the small, speckled *Ceratognathus* and members of a few related genera, make up the mobile element of our stag beetle fauna. They possess fully-formed hindwings and are capable of sustained flight, but others, comprising about one-half of the tally of our species, have settled down to become sedentary inhabitants of the wet forest floor. Here, conditions of temperature and humidity change but little throughout the year, and food, in the form of fallen timber, is abundant at all times. There is no need for great mobility and the beetles, in consequence, have lost their wings. Their wing covers (elytra) are fused together, across their backs, to form an effective shield for the soft hindbody and thus to protect the vital organs from damage while the beetles force their way through the rotten wood and humus that are their home.

Ground-frequenting stag beetles are dull-black creatures that spend their lives in semi-darkness, crawling, in sum, no more than a few yards from the site where they were born. Populations derived, originally, from a few widespread, winged ancestors of a bygone age, have persisted for many generations in restricted patches of mountain

Variation in two stag beetles. Above: *Lissapterus grammicus* (south-western New South Wales). Below: *Metopodontus torresensis* (Cape York). The beetle on the extreme right of each series is a female; the other specimens are males. The scale line equals 1 inch.



Above: The Golden Stag Beetle (*Lamprima aurata*), male (left) and female. (Scale line, 1 inch). Below: The larva of the Golden Stag Beetle. (Scale line, half an inch.)



forest. Isolated from their nearest neighbours by rivers and other natural barriers, they have, in the course of time, diverged sufficiently to form new species, so that today, each major range of the eastern Great Divide, from southern Queensland to Tasmania, possesses its own flightless stag beetle, related to but distinct from those on either side. The same situation obtains across the Tasman Sea, for the New Zealand species show similar distribution patterns and their relationships indicate a common ancestry with our own.

Life history

Adult stag beetles feed but little, their mouthparts being quite unsuited to masticating food. A few species visit flowers, to partake of nectar and pollen; others imbibe the resinous sap that exudes from wounded trees. Most species, however, subsist upon their fat reserves until they die. The life expectancy for active, flying species appears to be restricted to one or two summer months, but some of the sedentary species are known to persist as adults for more than a year. The Victorian *Lissapterus howittanus* is active at all seasons, even beneath a carpet of snow!

The female stag beetle lays her eggs in fallen, generally rotten, timber, where the larvae are destined to feed for several years before reaching maturity. The latter are typical "curl grubs" but they may be distinguished from those of the much more numerous and pestiferous chafers by their more slender build and vertical, rather than horizontal, anal slit. When fully fed, they construct an oval cell within or beneath the log and there await the coming transformation. Within a week or two a moult takes place and the pupa, a white, helpless creature, is revealed. Even at this early stage, the sex can readily be made out, for the exaggerated mandibles of the male lie, plainly visible, draped in their sheaths, beneath the chest. The pupal phase is of short duration and, within two weeks, the adult eyes and mandibles begin to darken. A few more days and the beetle is ready to emerge, but when it does so it is pale and soft and must remain quiescent for several weeks before the natural tanning processes have produced the hard, black or metallic armour of the fully-fledged adult.

[The photos in this article are by C. N. Lourandos.]

STUDY OF INSECT MIGRATION

The insect migration study scheme being carried out by the Australian Museum's Department of Entomology has now covered three breeding seasons of the Wanderer Butterfly (*Danaus plexippus*). Returns of marked specimens have been received at a slow but steady rate and amateur naturalists in many parts of Australia are becoming more and more interested in co-operating in the marking and releasing of specimens. This is long-term work, and it is encouraging to see that co-operaters are still forthcoming from other States, notably Victoria and South Australia, as well as New South Wales.

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