MARCH 15, 1960.

The AUSTRALIAN MUSEUM MAGAZINE

VOL. XIII, No. 5 Price—TWO SHILLINGS

The Numbat, or Banded Ant-eater, is one of the least known, though most remarkable, of the marsupials. An account of one of the few field studies of its habits ever made is given in an article on page 143.

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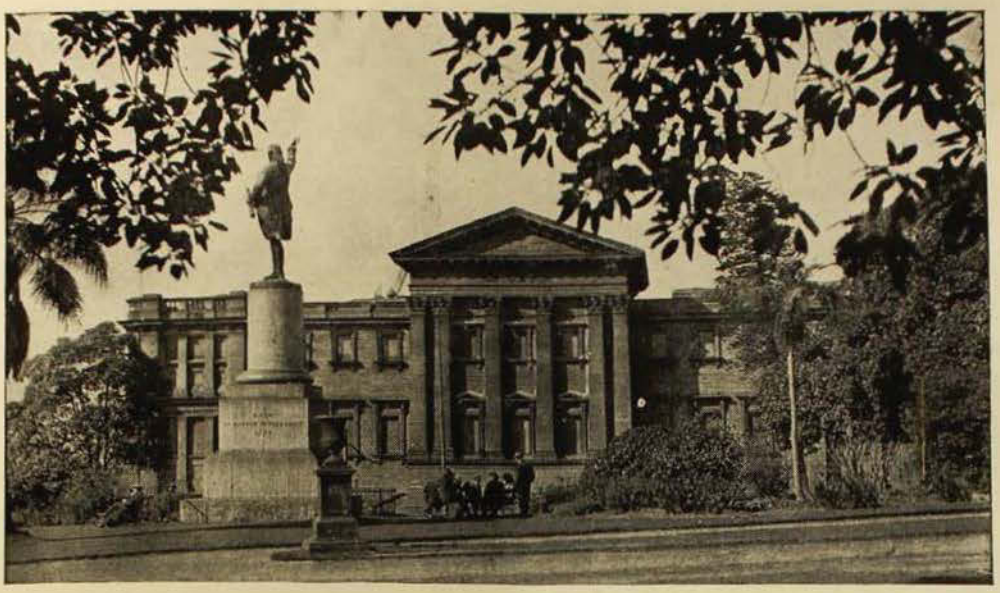

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• OUR COVER PICTURE, by Museum staff artist David Rae, shows a Numbat on a hollow log typical of those in which it hides when disturbed. The Numbat is a bright, active, handsome little creature which, fortunately, is rigidly protected by many farmers.

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KALGOORLIE — EL DORADO OF THE WEST

By R. O. CHALMERS

KALGOORLIE stands at an elevation of 1,250 ft. on the Great Western Plateau, which covers 90 per cent. of Western Australia and more than half the entire continent. A large portion of this plateau consists of a riverless region in which the occasional streams that do exist end up in salt lakes. Both streams and lakes are mostly dry.

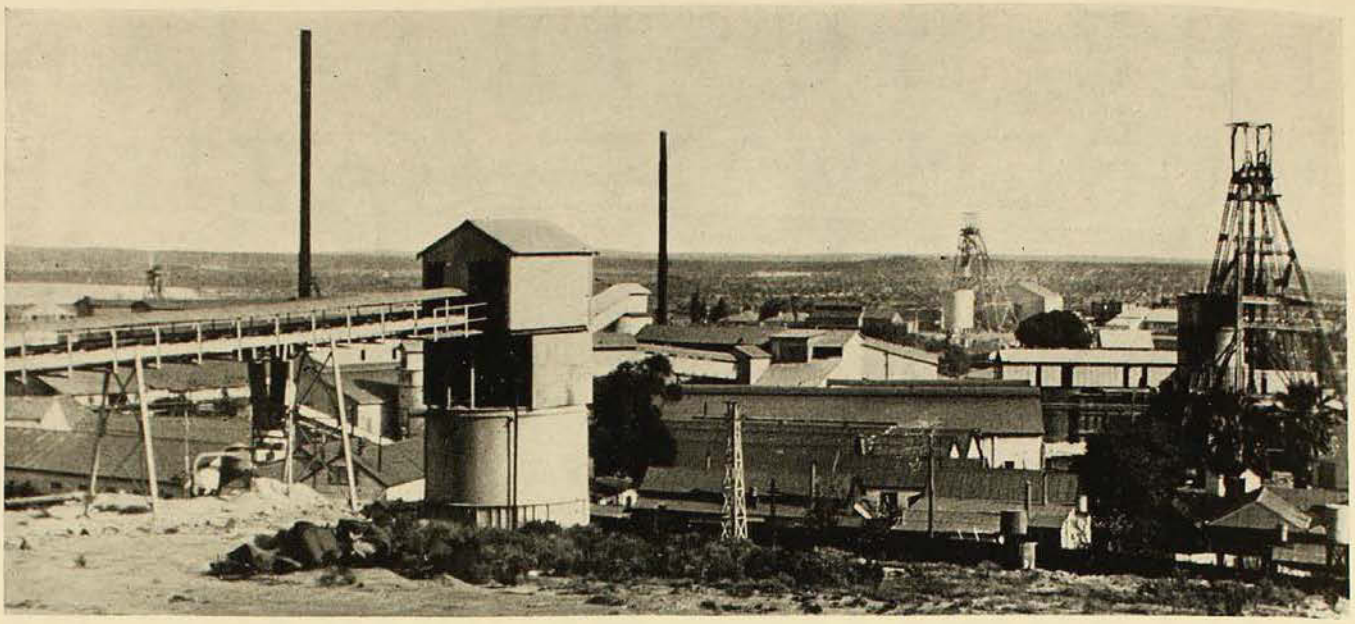
The Kalgoorlie region had never been traversed by early explorers, although Giles in 1875 had passed 100 miles to the north and Hunt in 1864-5 had actually reached to within 25 miles south of the present site of Kalgoorlie.

In the 'sixties, with the Western Australian population only some 15,000, and following the spectacular gold discoveries in New South Wales and Victoria, Government rewards were offered for the discovery of a workable gold-field in the more settled south-western part of the State. Strangely enough, the first important discovery of gold in Western Australia (in 1886) was not in the southern part of the State but in the Kimberley Division 1,300 miles north-east of Perth. This was followed by other finds, all in the remote north and north-western parts of the State.

In 1886 also, the magic words "There's gold in them thar' hills" were heard, relating to an area about 200 miles east of Perth. These hills were the Yilgarn Hills, the name being of aboriginal origin and meaning "white quartz". Southern Cross, the main settlement there, was established in 1888, and the field is still an important gold-producer.

Dissatisfied with the prospects at Yilgarn, enterprising and adventurous prospectors pushed further east under difficult conditions and in September, 1892, when the Yilgarn field was somewhat in decline, the most important event in the history of Western Australia took place. A prospector, Arthur Bayley, came into Southern Cross with 554 ounces of solid gold, chopped straight out of a quartz reef at a spot 115 miles to the east. He had left his mate, William Ford, to look after the find, for there were other prospectors nearby, and had returned to the nearest mining warden to register his claim as "Bayley's Reward."

There was an immediate exodus from Southern Cross. The better equipped parties went in camel teams, but lack of transport did not deter others. The luckier ones rode bicycles, but the rest walked, some pushing



The southern end of Kalgoorlie's "Golden Mile." The ore bin in the foreground and the headframe in the distance belong to the Lake View and Star Group's Associated and Ivanhoe mines, respectively. On the extreme right is the headframe of the Perseverance mine, owned by Gold Mines of Kalgoorlie Ltd. The chimney stacks and buildings adjacent to them are the Kalgurli Ore Treatment Co.'s.

Photo.—Author.

all their belongings in crude, home-made wheelbarrows. Many nearly met disaster through heat, privation and lack of water, and some did die on the track, but nothing could stop the greatest rush in Australian history since the days of Ballarat and Bendigo.

Thousands left the eastern States, then in the grip of the first of the great depressions which, due to this stroke of good fortune, left Western Australia untouched. Adventurers the world over flocked to the west, and in the 10 years from 1890 to 1900 the population quadrupled, reaching 180,000.

To return to Fly Flat, as the mining camp at "Bayley's Reward" was first called: All did not go well for many of the prospectors. A great number of them were driven back to Southern Cross through lack of water, but an adventurous vanguard pushed on to a prospective new field 24 miles to the east, leaving Fly Flat to be declared a municipality in 1894, under the better-known name of Coolgardie.

On the new field Paddy Hannan struck gold and registered his find simply as "Hannan's" in June, 1893. Once more the rush followed, and in 1895 Hannan's find became officially known as Kalgoorlie, a corruption of the aboriginal word "kalgurli," said to be the name of a shrub. Paddy Hannan first discovered his gold lying in soil shed from one of the small hills on the north end of a broad low-lying ridge that ran north and south for about six miles. Alluvial mining, which was never particularly promising, gave place to underground mining as ore deposits were discovered along the whole length of the ridge. The most productive part of the whole field is the "Golden Mile", said to be the richest square mile of ground in the world. It runs for three miles at the southern end of the ridge. For the last 60 years it has bristled with head-frames, chimneys, smelters and refineries, the outward sign of the great wealth it has brought to the whole of Australia.

Goldfields Water Scheme

Within five years Kalgoorlie had a population of 25,000, and really consisted of two towns—Kalgoorlie proper at the northern end of the Golden Mile and Boulder at the southern end.

Kalgoorlie, Coolgardie and the whole district for hundreds of miles around lie in the riverless region of Western Australia. The

low yearly average rainfall of only 9½ in. and the very high summer temperatures made it imperative to provide a reliable water supply. Work began on the Goldfields Water Scheme in 1898, and by 1903 a pipeline ran 351 miles to Kalgoorlie from the Mundaring Weir in the Darling Ranges, 26 miles from Perth. In this notable engineering scheme a number of pumping stations lift the water to the necessary level. Transport problems were solved by the extension of the railway to Kalgoorlie in 1897. Kalgoorlie is a most important transport centre because, since 1917, it has been linked with Port Augusta in South Australia by the Transcontinental Railway, a distance of 1,051 miles.

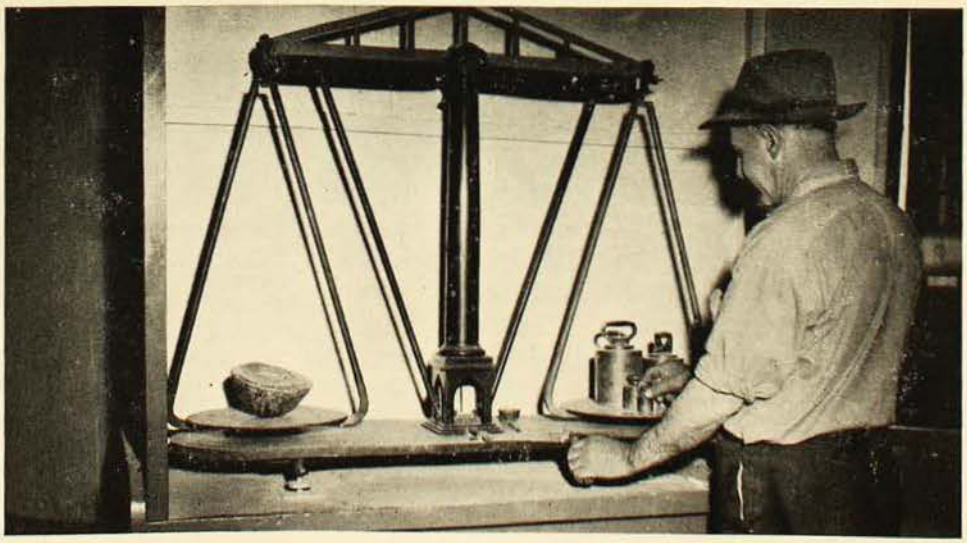
Gold In "Greenstone"

The popular conception of gold invariably occurring in quartz is not entirely correct. Kalgoorlie is one of a number of important gold-fields throughout the world that are exceptional. The gold at Kalgoorlie occurs in a rock known as "greenstone", so called because of its colour.

The "greenstone" is made up of a number of members. The earliest of these were poured out as hot, molten lava flows from vast eruptions on both the then existing land surface and the sea-bed. This group of rocks is known as the "Older Greenstones". Normal sedimentation continued with the deposition of shales and sandstones. (Some of these latter today provide attractive building stones of a prevailing cream and pink colour, and have been used in at least two imposing buildings in the district, the Kalgoorlie Post Office and the Coolgardie Municipal Buildings). After the deposition of these sediments an intrusion of quartz dolerite forced its way in between the sediments and the "Older Greenstones". This is known as the "Younger Greenstone", and it is in this that the gold was deposited from solutions, derived from some deep-seated source, which gained access through faults and fractures that developed because of intense folding in the whole "greenstone" system. The auriferous sections often cannot be distinguished from the barren country rock, and the presence of payable gold must be determined by assay.

These events occurred in the dim mists of geological antiquity, because not only in the Kalgoorlie district, but throughout Western Australia, particularly in the southern and south-western districts, the greater part of the rocks now found on the surface originated in the Archaeozoic period, the very early part of Pre-Cambrian time, some 3,000 million years ago. The "greenstones" owe their colour to the intense alteration they have undergone. Similar gold-bearing "greenstones" also occur in the Murchison and Pilbara districts of the State. In fact, 90 per cent. of Western Australian gold occurs in these very characteristic rocks.

There are other unusual features about Kalgoorlie gold deposits. Exceptionally rich masses of gold-bearing "greenstone"



Weighing a gold ingot at Kalgoorlie.

Photo.—Western Australian Government Tourist Bureau.

have been found. These are known as ore chutes, and the most famous of them was the Oroya chute. It was worked along a length of over 4,000 ft., and gold to the value of £7,000,000 was extracted from it. The widespread occurrence of tellurides of gold and silver in association with the native gold is an unusual mineralogical feature. In very rich ores these minerals are quite visible, and many superb specimens have been found. While the Australian Museum displays quite good representative specimens one must go to Kalgoorlie and see the outstanding ones in the possession of the mining companies. It was, however, a privilege to see in Sydney in 1956 the magnificent specimens brought there by Mr. Spencer Compton, a well-known Kalgoorlie geologist and authority on the history of the Eastern Goldfields in Western Australia. The two principal telluride minerals are chemical compounds of gold, silver and the semi-metallic element tellurim. Both have a pronounced metallic lustre. Calaverite is golden because the amount of gold in it predominates over the silver. It was first named after Calaveras County, in Colorado, U.S.A., one of the few localities in the world, besides Kalgoorlie, where these rare minerals occur abundantly. Sylvanite, as the name would suggest, is a silver-rich telluride mineral, and is steel-grey to silver-white.

Huge Production Figures

Ever since the discovery of Kalgoorlie, Western Australia has been the chief gold producer in Australia. Sixty million ounces (1,850 tons) of rich yellow gold, worth £417,000,000, have been won in that State, and of this just over half has come from Kalgoorlie alone. The peak production of a little over 2,000,000 ounces, worth nearly £9,000,000, was in 1903. There was a steady decrease until, in 1929, an all-time low of only 400,000 ounces, worth £1,750,000, was reached. It is well known that this precious metal has no particular use other than as currency, and, as a consequence, accurately reflects crises such as wars and depressions, both major and minor.

One must hasten to add that the total value of gold produced in Australia is still about 40 per cent. of all Australian mineral production, although since 1942 the annual value of coal produced has exceeded that of gold, and since 1945 the annual combined value of silver-lead-zinc has also exceeded it. It should be remembered, in comparing these figures, that the price of gold is fixed and does not fluctuate.

Since 1945, Western Australian gold production has risen until, for some years now, the annual production has been over 800,000 ounces, worth £13,000,000, with Kalgoorlie producing about 60 per cent. of this total. For some years the total annual production of gold in Australia has been over £15,000,000. Up to the end of 1957 Western Australia had produced 34 per cent. of the total Australian gold yield of 175,651,860 ounces, and so has not yet reached the record Victorian figure of 42 per cent. If present production is maintained Western Australia should exceed the Victorian total in about 14 years.

Kalgoorlie's production now considerably exceeds the individual production of both Ballarat and Bendigo, making it the most important single gold-field in the history of Australia.

The fortunes of Kalgoorlie itself have fluctuated with variations in production. It now has a population of 25,000—about the same as it had at the beginning of the century. The town is pleasantly laid out, with wide streets and an abundance of trees, and gives the same impression of prosperity as does Broken Hill, which it resembles in many respects, including area and population. As in Broken Hill, it is now difficult to imagine the hardships endured by the pioneers. Faith in Kalgoorlie is strong. Geologists and mining engineers, in addition to developing existing ore bodies, are busily engaged in surveying and drilling the surrounding districts in the hope of discovering extensions of those bodies.

The Numbat of South-Western Australia

By J. H. CALABY

Wildlife Survey Section, C.S.I.R.O., Canberra

THE Numbat, or Banded Ant-eater, is a small marsupial which has many claims to distinction, even in an order of mammals noted for its distinguished members.

It is somewhat larger than a rat, and has a head-and-body length of about 9½ in. and a tail roughly 7 in. long. It weighs a little over a pound. It is the most beautifully coloured of the marsupials; the general colour above is greyish-brown to reddish-brown, with a varying admixture of white hairs, and there are several prominent white bars across the back and rump. Between the white bars on the rump the hair is dark, sometimes almost black, but there are always a few white hairs mixed in. There are a whitish stripe above the eye and a dark stripe through the eye. Underneath, the hair is almost white. Most of the body hair is short and coarse, but the tail hair is long and the tail has a bushy appearance when the hair is erect.

The Numbat has a sharp face and a long worm-like tongue which can be protruded for several inches. These adaptations facilitate the gathering of its food, which consists almost solely of termites and ants. The teeth are degenerate and vary in number from 50 to 52, the largest number found in any land mammal.

The Numbat is an aberrant member of the Dasyuridae, the family which contains the native cats, marsupial-mice and related insectivorous and carnivorous marsupials.

There is still some argument as to whether it should be placed in a family of its own, but it has many characteristics in common with the dasyures. For example, the molar teeth, although degenerate, closely resemble dasyurid teeth; the number and morphology of the chromosomes are identical with those of all other dasyures, and certain behaviour patterns of the Numbat are dasyure-like.

Two Sub-species

There are two sub-species of Banded Ant-eater—*Myrmecobius fasciatus fasciatus*, of south-western Australia, and *M.f. rufus*, which is now confined to desert areas of the eastern part of Western Australia and adjacent parts of South Australia, but which formerly occurred as far east as western New South Wales. The latter sub-species differs from the typical one in the brilliance of its colour, the main body colour being a kind of rich brick-red.

In spite of the fact that the Numbat was discovered more than 120 years ago, very few original observations have been published on its habits in the wild. In an attempt to remedy this deficiency, the writer carried out a field study in the bush around Dryandra, a small forestry settlement about 100 miles south-east of Perth.

The Numbat lives in woodland which is really an open eucalypt forest with a shrubby floor. Over most of the present-day range of the animal the most abundant species of tree is the Wandoo (*Eucalyptus redunca* var. *elata*). A high proportion of the mature Wandoos are attacked while living, and the heart-wood eaten out by *Coptotermes acinaciformis*, the most destructive of Australian termites. The woodland floor is littered with fallen hollow limbs and branches blown from the infested trees. The logs are essential to the Numbat, for they provide shelter and escape. Together with sticks, leaves and other litter, the logs also provide the bulk of the food for the termites on which the Numbat feeds.

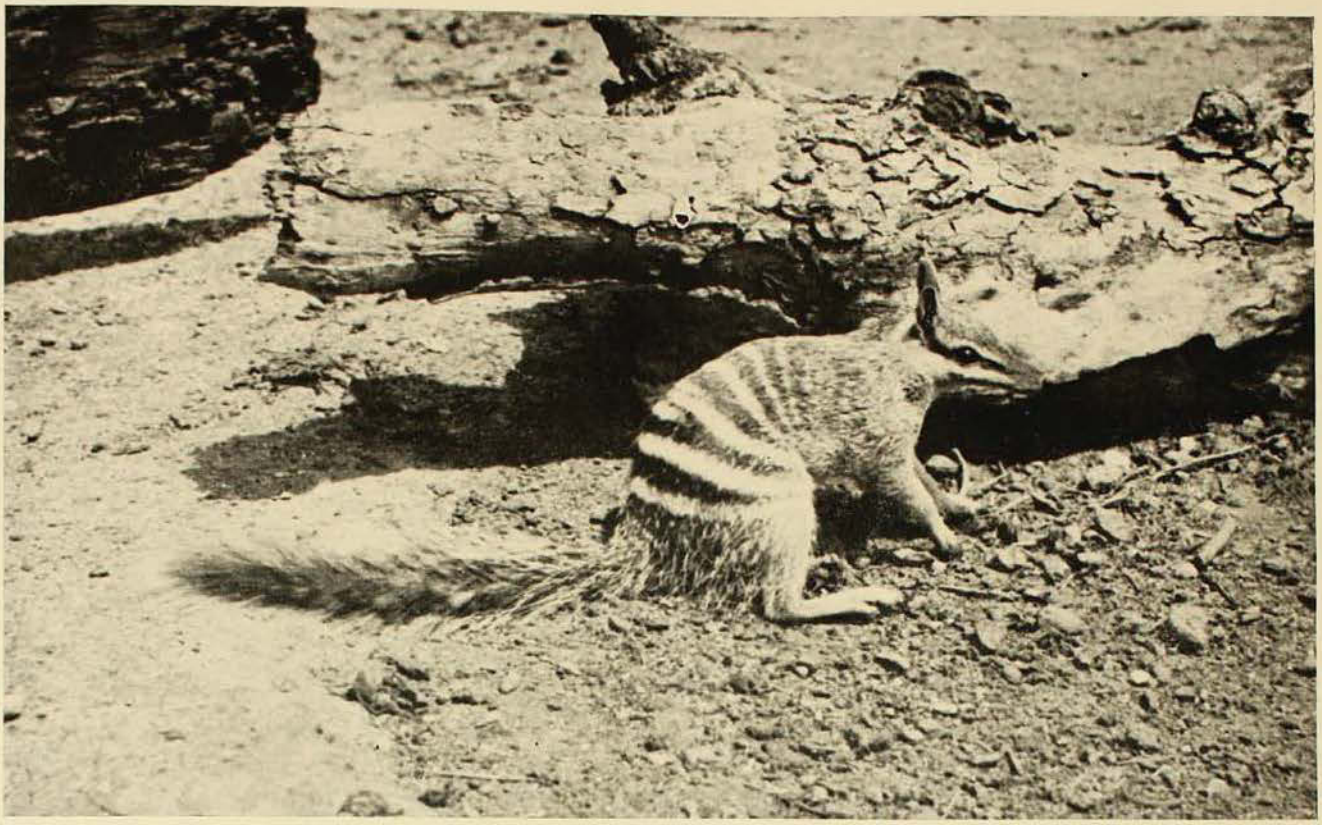
Busy Little Animal

Numbats are quite unlike most small mammals in that they are abroad in the daytime and not at night, and can therefore be watched with binoculars in much the same manner as birds. They were usually located by driving slowly along bush tracks. Provided the observer was quiet and did not approach too closely or get out of the car, the animal would usually carry on with whatever activity it was engaged in. In general, it appears to be a solitary animal, and it was not usual to see more than one together, except in spring, when the young were about.

The Numbat seems to be a very busy little creature. Many of its movements are jerky, like those of a number of small marsupials and of higher mammals such as squirrels. A good deal of its time is spent in searching for food. In the cooler months it does much sun-basking, either sitting up on the ground or lying out on logs. If it is suspicious of a car or other strange object it

Bush in the Dryandra district, Western Australia, in which the author made his observations of the habits of the Numbat. The trees are Wandoos, a species of *Eucalyptus*. The small shrubs are Sandplain Poison (*Gastrolobium microcarpum*).

Photo.—Author.



A Numbat in a typical alert stance. It has been disturbed while searching for food.

Photo.—Charles Barrett.

walks or trots away, stopping every few yards to elevate its body and look around. The sight of a human usually causes it to run to a hollow log, and, if not hard-pressed, it will stop at the entrance and "stand up" and look around before entering. When surprised at close range or when released after handling, the Numbat flicks its tail up over its back, erects the tail hair (giving the tail a very bushy appearance) and runs to the haven of a hollow log. When captured, it never attempts to bite or scratch; its only protest, other than attempts to escape, are a low throaty growl or hissing sounds.

The Search For Food

The Numbat searches for food by walking slowly along, smelling the ground here and there. If termites, which are abundant in the sub-surface soil, are located, it sits on its hind feet and digs rapidly in the soil, stopping frequently to lick up the exposed insects. It also turns over sticks and chips in its search for termites.

The food of the Numbat was ascertained by collecting the exposed insects from the places where it was seen feeding, and also by collecting samples of faeces and examining them with a microscope. Invertebrates other than termites and ants were eaten in negligible numbers. Fortunately, the fragments of termites and ants which pass out in the faeces are sufficient to identify specifically the majority of species eaten. The Numbat's diet consists largely of termites, but a fair proportion of ants is consumed. The different species of termites are eaten roughly in proportion to their abundance in the places where the little animal feeds, but the ants eaten are mostly the small predatory species. It seems that the latter are mostly ingested accidentally. When termites are exposed by the Numbat, the ants run in to share the meal with it, and are thus lapped up. It was interesting that the destructive termite species which attacked the trees and so provided the Numbat with its hollow-log shelters was also the most important food item.

The Numbat's Young

The young are born from January to March, and probably a month or so later. The normal litter is four, and they are carried or nursed by the mother through the winter. The Numbat has no pouch, and the young are securely held by the teats, which swell in the mouth, as in all marsupials. The young also cling tightly with their hands to the long hair of the mother's belly. By late August and September the young are detached from the teat and are living in a nest in a hollow log or a hole in the ground. Juveniles have been observed foraging for food on their own in October.

The Numbat's range in south-western Australia has shrunk considerably since European occupation, but colonies are known in many widely-scattered places. In spite of written statements that it is rapidly vanishing, it would be true to say that it is one of the more abundant of the small mammals of this region. Predators and bush fires, which are often stated to be endangering it, do not seem to be of much importance. There is no doubt that the chief factor contributing to the decrease in its range at present is the clearing of the land for agricultural development. However, there seems to be no reason why the Numbat should not persist indefinitely. It occurs on a number of forestry and water-catchment reserves, and the number of reserves can be expected to increase. The Numbat also lives in "bush blocks" on private property. Many farmers are aware of its presence on their properties and rigidly protect it. In fact, there is a growing public sentimental attachment to this bright and active little creature which could assure its future in much the same way as public interest has helped the recovery of the Koala in eastern Australia.

A Numbat among leaf litter.

Photo.—Charles Barrett.

Ancestor Worship Among the Melanesians

By FREDERICK D. McCARTHY

THE family problems created by the mother-in-law are well recognized and provided for in the social life of the Melanesians of the western Pacific. The dead present a greater problem than relatives, as the religion of these people is for the most part one of animism, or ancestor worship, in which the ghost, spirit or soul, whatever this spiritual essence of man be called, is so intimately bound up with the life of the living that every personal and group activity is governed to a considerable degree by the goodwill and sanction of the ghosts of the dead.

In some areas, several of which are dealt with in this article, the skulls of dead men were preserved in a variety of ways for religious purposes. As women and children lacked the magical *mana* power acquired by the men through initiation and other religious associations, their skulls were of no significance. Government and missions have now enforced burial of the dead in cemeteries; consequently, the remarkable skull curios of the old days are no longer made, and those in existence are of considerable value.

The family and personal relatives, in groups, clans, secret societies and similar socio-religious units of society, suffer a great loss by the death of a man, particularly a chief, ritual leader, wealthy and highly ranked member of a secret society, a great warrior, magician or fisherman. The community is reluctant to part with him, so prolonged or delayed ceremonies for the disposal of his body and spirit are carried out. The living like to demonstrate their affection for a dead man, and fear to offend his ghost in any way.

In the central and western Solomons the Rev. H. R. Codrington recorded, between 1867 and 1883, the wealth of mythology, art,

This 9 ft.-high *rembaramp* was a memorial to a wealthy man who held high rank in secret societies on Malekula Island, New Hebrides. His skull, with the face moulded from a vegetable paste, forms the head. The body and limbs are made of wooden poles, tree-fern fibre and paste. An ancestor's jaw is held in one hand and a shell in the other.

magic and ceremony which surrounds death and ghosts. There, a man of ordinary ability who had lived a normal life and attained no fame could only expect to live such a life in the spirit world and not be remembered by his community to any degree. But the chiefs and leaders in various spheres of life, by right of status and *mana*, achieved a certain immortality, sometimes permanent, in the religion of their people.

In the Solomons fishing for bonito was an important group activity. Frigate-birds, which heralded their approach, and sharks and swordfish, which accompanied or attacked them, figured prominently in the fishing ritual and as familiars for ghosts of great fishermen and other men.

A man could will his spirit to live in any particular one of these creatures after his death. Sharks were favoured because they were plentiful in the seas, frequenting popular fishing, shore and reef resorts. A man would offer valuable porpoise teeth or food made from grated coconut, yam and pig's flesh to the shark he had selected for the purpose. He spoke loudly with the voice of a ghost, demanding to eat of this food. The people studied such a man, and, if sure that he had *mana*, would accept his spirit as a *tindalo* (the San Cristoval name, but the name varies with the language) ghost at his death. A huge eel in a pool, crocodiles and other animals became associated with *tindalo* ghosts, and the frigate-bird ones were of special importance because of the value of these birds to fishermen and mariners.

The ghosts of some men became *tindalo* fortuitously. For example, a man planted a patch of coconuts and almonds in the bush. After he died a rare white cuscus, believed to be his *tindalo*, appeared in the grove, and thereafter nobody collected the nuts.

Shrines And Images

After the funeral and mourning ceremonies, the skull and a few other bones of a man were exhumed and placed in the shrine of his *tindalo*. This shrine was a rock on the seashore or in a garden or the bush, a house or part of a garden fenced in, a grave, or a grove of trees. Personal possessions, such as a lime stick or pot, ornaments and the like, were deposited in the shrine, and some of these relics of great chiefs of the past were many generations old. Thus, Daula in the sea, Pelu in the gardens and Hauri in fighting, were ancient *tindalo* known everywhere but invoked only by chiefs.

Fine wood carvings of ancestors and *tindalo* animals were placed in the canoe and club houses, or fashioned in relief on the posts of these structures. Sometimes the skull of a great fisherman was placed in a cavity in a large carving of a swordfish, shark or bonito. The shrines and images were not inhabited by the ghosts, nor had they any *mana* in themselves; they were merely symbols through which specified individuals had access to this power of the *tindalo*.

The shrines and carvings demonstrated how the people honoured their great ancestors and chiefs, whose place was thus retained in the community. By offering food to the ghosts and decorating the shrines with flowers and leaves, the people showed their desire to please the ghosts. Thus,

This Sepik River (New Guinea) man's face was remodelled in clay on his skull and painted white with a red line pattern. The original hair was used, while cowry shells serve as eyes.

Preservation of the heads of great men was part of the Melanesians' cult of ancestor-worship. *Top left*: Only the front of the skull was preserved in New Britain. In this example, the features are modelled in clay and painted red and black. Grass fibre represents the beard worn by these islanders, and shell opercula serve as eyes. *Top right*: This elaborate Sepik River (New Guinea) head is painted brown and decorated with cowry and other shells. *Bottom left*: In the central and southern Solomons the faces were modelled with Parinarium Nut gum, painted black and inlaid with pearl shell. Teased fibre was used for the hair. *Bottom right*: This dried head of a Maori chief has the original tattooed skin and hair.

although the carvings were not sacred in the sense of being ritual objects which women could not see, they were regarded with the greatest respect, and the shrines were not trespassed upon. The ghosts (some never became *tindalos*) and *tindalos* were dangerous unless the behaviour of individuals and communities towards them was correct. Unless traditional patterns of etiquette and sacrifice were followed a *tindalo* would bring about illness, death, failure of fishing and crops, defeat in war and head-hunting raids, and the wreck of canoes.

Special Sacrifices

To avert or overcome these disasters sacrifices were made to the *tindalo*. The first fruits from the almond and canarium nut trees, yams and other plants were offered at the respective shrines. For example, a yam was placed beside the ancestor's skull and the leader of the rite exclaimed, "This is yours" in a loud voice, while the company of men present named their important ancestors. Each man brought yams from his garden to the shrine and took back one permeated with the *mana* of the *tindalo* to put with personal relics of the dead in his house. The first flying fish and bonito caught were similarly offered to the *tindalo*, and special foods to the sharks, crocodiles eels and other *tindalo* animals in the sea.

So sacred were these animals that if, for example, a man escaped from the attack of a shark known and named as a *tindalo* shark he would be thrown back into the water to drown. If a flying-fish leaped from the water and touched a man in a canoe or on a reef he would die from his illicit contact with a ghost.

Special sacrifices were made to the *tindalos* to cure sickness or crop failure, either with food or by burning a pig or a dog at the shrine. If the *tindalo* could not be identified a magician was consulted.

Tindalos were believed to fight with spears for the possession of sick people. When a man paid a magician a pig to bring about the death of another man, the latter would retaliate in the same way, and the ghosts involved would fight to decide which one of the men was to be the victim.

In ventures like war, head-hunting and bonito-fishing, and in the growing of yams and similar important crops—all matters of community importance—public sacrifices were made by the village chiefs, who uttered special formulas of appeal to the *tindalos* at the shrines during the rites. Criminals were sometimes sacrificed on these occasions.

At the shrine of Ganindo, a great warrior who died from an arrow wound in the neck, his betel-nut, lime-box, shell trumpet and limb bones were deposited with his skull in a basket. After a successful head-hunting raid the warriors threw a spear into the house forming the shrine, and in gratitude built him a new one with carvings of himself and his two sisters on the posts.

Men who could communicate with *tindalos* were believed to be able to persuade them to create a calm or storm at sea, and to bring sunshine or rain, happenings which could help their own people or harm enemies. Others could ascertain whether a canoe voyage would continue safely—by a *tindalo* rocking the craft—or whether it would be advisable to return.

The assistance of a *tindalo* was sought in conferences when difficult decisions faced a community's leaders. The power and status of a chief depended on that of the *tindalo* on whom he could rely, and when a *tindalo* failed it was abandoned for another one. People bereft of their senses were believed to be possessed by a *tindalo*.

Faces Moulded In Paste

According to Bernard Deacon, respect for the spirits of the dead among the Melanesians in the New Hebrides depends on the rank attained by a man in the three secret societies on the island. In the old days a *rembaramp* memorial was made for a man of the highest rank. The skeleton of such a person was put in his clan's shrine, but the skull was used on the *rembaramp*. On the day the skull was removed the clansmen made a frame of wooden poles, on which tree fern was used to represent the body, and a paste (made of sawdust rubbed from a sacred creeper, tree-fern fibre, coconut milk and breadfruit juice) was shaped into the limbs. The face of the dead man was

The face of this Malekula Island (New Hebrides) man is modelled on his skull with a paste made of sawdust from a sacred creeper, tree-fern fibre, coconut milk and breadfruit juice. It is painted black, with a design in red and orange.

moulded in this paste on to the skull to form the head of the image. Black feathers on the shoulder spikes and head symbolized the man's membership in the Nimangki Society, as also did painted designs, turtle and shell armlets and boars' tusks on the arms and chest. Hawk's feathers on the head represented the ranks entered. Shoulder faces stood for his membership of the Nevinbur society. A conch shell held in his hand was broken by him when he entered the highest rank of the Nimangki society. An ancestor's lower jaw may be held in one hand. A mask on the head was a link with the Nalawan society.

Rembaramp's Last Resting-Place

Thus, men who had striven all their lives to attain higher and higher ranks in these societies, and status in their villages, were finally rewarded with such esteemed images. The *rembaramp* was borne from the club-house to the great standing wooden gongs, thence to the deceased's house door (where the widow stroked and wept over it), then back to the gongs and to its final resting place in the club-house. There, sprigs of croton and other plants were put on it during the commemoration of the dead, but when it decayed the skull was put in the clan's shrine.

In Polynesia the skull of a chief was removed to a family shrine to save it from insult in time of war. Maori families wept over the heads of dead chiefs from time to time, even borrowing them for this purpose from an enemy village which had slain the chiefs in battle. A village which possessed the head of an enemy chief reviled and insulted it in every possible way. Families whose members had been killed in battle against the dead chief were particularly active in reviling it. In battles, a chief's head would be offered to his men, who acknowledged defeat if they accepted it, and continued the struggle if they did not. Revenge for the chief's death, and for the deep insult of enemy possession of his head, instigated retaliation at the first opportunity. The great demand in Europe for these tattooed heads (the more tattoo the better) inspired much savage and unnecessary killing of chiefs during the early days of New Zealand's occupation.

[*All photos in this article are by Howard Hughes*]

The Unique Plants and Animals of South-Western Australia

By ALLEN KEAST

THE forested south-western corner of Western Australia, isolated as it is from the east by the arid and treeless Nullarbor Plain, is in many ways the most interesting part of the continent.

Various distinctive animals are confined to it, a fact that has led one or two zoologists to regard it as a distinct faunal "sub-region". Its animals do not, however, in any way approach its plants in distinctiveness. To the botanist, it is one of the really striking areas of the world.

The flora of south-western Australia has four features of outstanding interest:

• A degree of endemism in terms of species (i.e., of plants entirely restricted to it) that reaches about 80 per cent. Mr. C. A. Gardner, the Western Australian Government Botanist, has described this figure as "remarkably high—perhaps the highest in the world" for a single area. It is to some extent, however, rivalled by the Cape Province of South Africa.

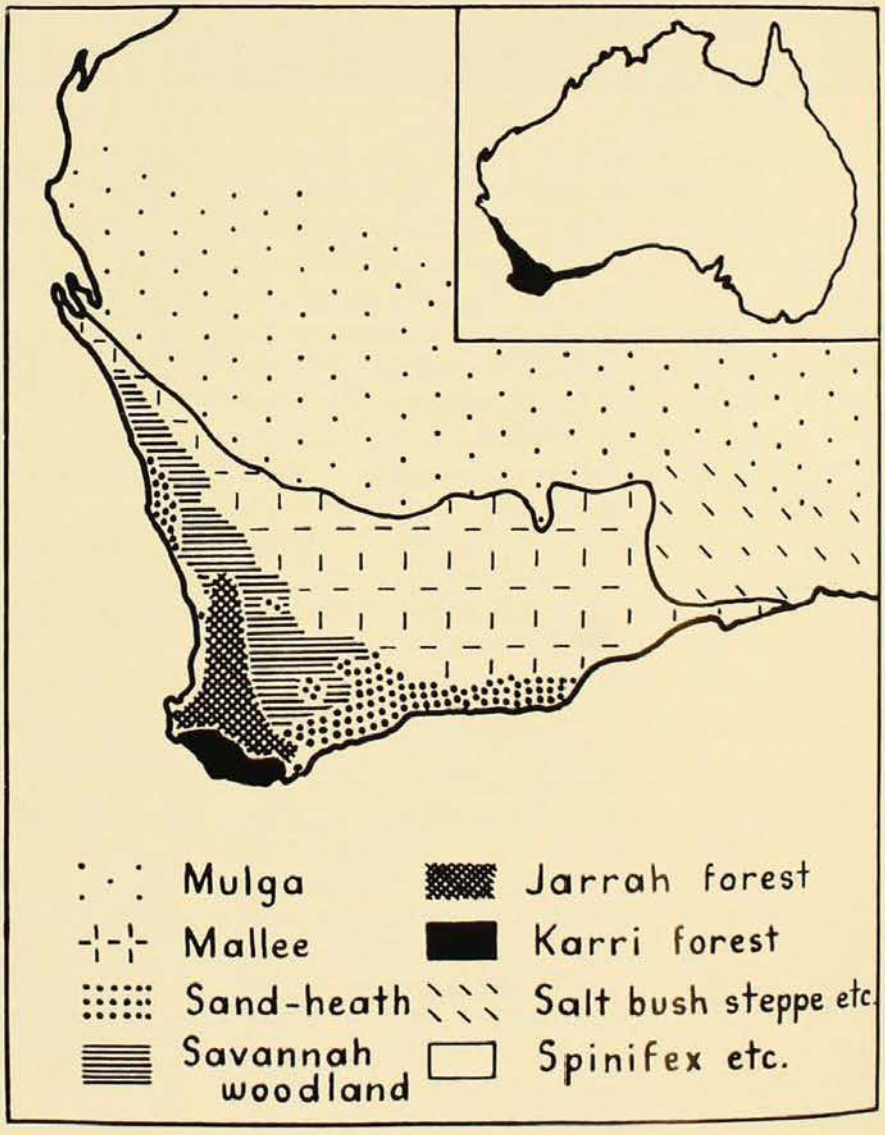


Fig. 1: The large map shows the major vegetation sub-divisions of south-western Australia. The inset map shows, in black, what is known as the south-western province, the Karri, Jarrah, sand-heath and savannah woodland country in which south-western Australia's unique endemic elements occur. The continuous line in the large map is the "mulga eucalypt line" of Western Australian biologists, north of which is desert covered with Mulga scrub.

After Gardner (1944), with modifications from the vegetation map in the Atlas of Australian Resources (1955).

• The remarkable total of more than 6,000 species of plants, a figure which, it has been stated, is excelled by no other area outside the tropics.

• Even more significant from the Australian viewpoint, however, is the fact that most of what are known as the true, or basically, Australian plant groups reach their greatest development and abundance in south-western Australia. Thus, of the 50 species of *Banksia* 37 are restricted to the south-west, as are 106 of the 120 species of *Melaleuca* (one of the genera of tea-trees). One-hundred-and-twelve of the 180 species of *Grevillea* are confined to the area, along with 71 of the 100 species of *Hakea* and 26 of the 30 species of *Isopogon*.

• Apart from the above, the south-west has two very distinctive plants, the pitcher plant (*Cephalotus follicularis*) and the orange-flowering Christmas Tree (*Nuytsia floribunda*).

In the former, which is the sole representative of a unique family of plants, half the leaves are modified into remarkable insect-trapping structures (the pitchers). These have a hairy outer wall that enables the prey to climb readily to the attractively-smelling liquid inside, but once there they are trapped by the stickiness of the inner walls and by a palisade of recurved spines. Soon they fall into the fluid, where powerful digestive enzymes quickly disintegrate them. The "pitchers" are surmounted by a lid that keeps the rain from diluting the fluid within. *Cephalotus* has a superficial resemblance to, but no relationship with, the true pitcher plants of the tropics (*Nepenthes*).

Nuytsia is actually a mistletoe (Loranthaceae) that has developed into a tree. It is a parasite, at least when young, drawing its nourishment from the roots of other trees in the vicinity.

The famous botanist, Sir Joseph Hooker, was the first to study and appreciate the significance of the flora of south-western Australia, writing of it as long ago as 1850. Alfred Russel Wallace wrote in 1880: "The peculiarities presented by the south-eastern and south-western subdivisions of the flora of temperate Australia are most interesting and suggestive and are, perhaps, unparalleled in any other part of the world. South-west Australia is far less extensive than the south-eastern division—less varied in soil and climate, with no lofty mountains, and much sand desert; yet, strange to say, it contains an equally rich flora and a far greater proportion of peculiar species and genera of plants."

The South-Western Province—Its Climate, Soils And Major Vegetation Sub-Divisions

The south-western province (Fig. 1) is bounded by sea on one side and desert on the other. Its limits inland are about the 20-inch rainfall line that marks the transition from the savannah woodland and sand heath country to the mallee (Fig. 2). Actually, it is fairly diverse in terms of plant formations.

The Karri (*Eucalyptus diversicolor*) forests in the far south-western corner are of the "wet sclerophyll" type, i.e., composed

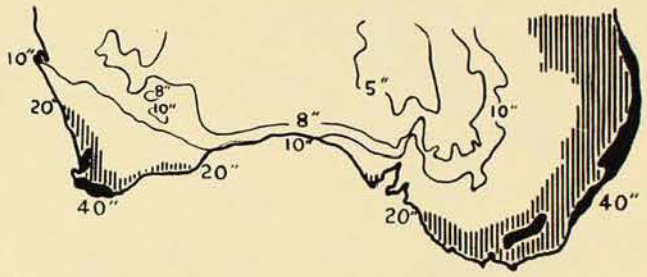


Fig. 2: The barrier isolating the flora and fauna of south-western Australia today is a climatic one, reinforced by inroads of the sea (the Great Australian Bight and Spencer's and St. Vincent's Gulfs) and vast areas of unsuitable soils. The 10 in. line of average annual rainfall indicates the extent of desert. The general correspondence between the 40 in. and 20 in. rainfall zones and the distribution of Karri and Jarrah in the south-west will be noted.

of large trees with somewhat lush undergrowth. Karri trees grow to 300 ft. in height, have smooth white trunks and require hilly areas with light soil and a rainfall exceeding 40 in. a year.

Slightly more inland, the Jarrah (*E. marginata*) forests are to be found. These are of a somewhat drier type, and they grow on porous lateritic soil. The trees are tall and have a coarse bark. Further inland again is savannah woodland, park-like and with little undergrowth other than scattered shrubs.

The fourth vegetation formation is the sand heath. This consists of stunted shrubs, often as low as 2 ft. to 3 ft., and growing on deep sand or sandy-gravelly terrain. Unexpectedly enough, the sand heath contains the bulk of the botanical diversity of the south-west. It is here that most members of the distinctive genera referred to occur. The spring flowering in the sand-heaths is nothing short of fabulous.

Vegetation formations needless to say, have a strong influence on animal distribution, many species being confined to one or the other of them.

The Animal Life Of South-Western Australia

The south-western forests have a good quota of animals, though perhaps only 70-80 per cent. of the number of species of birds and mammals that would be found in an equivalent forested section in the south-east. The familiar types are nearly all present, but a few, like the Lyrebird, Azure Kingfisher, Dollar Bird, Koala, Wombat and Glider Possums, are lacking. Some of these may never have succeeded in reaching the area but, as we know from fossil evidence, others, like the Koala and Wombat, were formerly there and have died out.

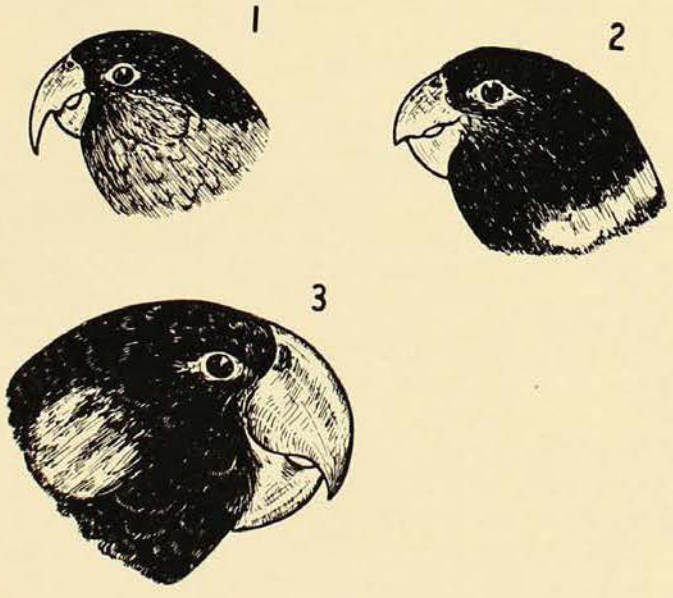


Fig. 3: (1) The bill of the Red-capped Parrot, with its long upper mandible, a special adaptation. Mr. Angus Robinson, who has studied these birds in the field, states that this mandible enables them to delicately lift the seeds from the large capsules of the Marri and other characteristic Western Australian trees. (2) and (3) The more generalised bills of the Twenty-eight Parrot and the White-tailed Black Cockatoo. These must break open or crush the capsules to get the seeds.

There are two distinctive species of birds without counterparts in the east, the Red-capped Parrot (*Purpureicephalus spurius*) and the White-breasted Robin (*Eopsaltria georgiana*). The former is interesting in that it has a greatly lengthened upper mandible (see Fig. 3), apparently a specialization for extracting the seeds from the large capsules of the Red Gum or Marri (*Eucalyptus calophylla*) and Jarrah (*E. marginata*).

Certainly, this species, which consumes a range of other foods from *Casuarina* and *Banksia* seeds to apples, does a much neater job opening the Marri capsules than do the Twenty-eight Parrot (*Barnardius*) and the White-tailed Black Cockatoo (*Calyptorhynchus*).

The strangest mammal confined to the south-west is the Honey Possum or Honey Mouse (*Tarsipes*). This small creature lives on nectar and insects, apparently moving around seasonally to coincide with the flowering of the tea-trees, *Banksias*, and other plants. It has a remarkably long muzzle, "tubular" lips and a "brush" tongue, all special adaptations for obtaining nectar and a striking parallel to what is typical of the honey-eating birds (Meliphagidae). This will be seen from Fig. 4.

The short-bodied wallaby known as the Quokka (*Setonyx*), characterized by an unusual tooth-structure, also lacks a counterpart in the east. However, the Numbat (*Myrmecobius*), though it only survives in the south-west today (and probably originated there), formerly occurred as far east as the Victorian mallee.

Since settlement one south-western bird, the Noisy Scrub-bird (*Atrichornis clamosus*), has become extinct. Several mammals have become very rare, and a couple of kinds may have died out.

Amongst the lesser-known groups of animals there are many distinct forms. A tortoise and a couple of basic types (genera) of snake-lizards and snakes are confined to the south-west. There are two intriguing frogs—the terrestrial "White-ant Eater" (*Myobatrachus gouldii*), which is believed to have the unusual habit of retaining its

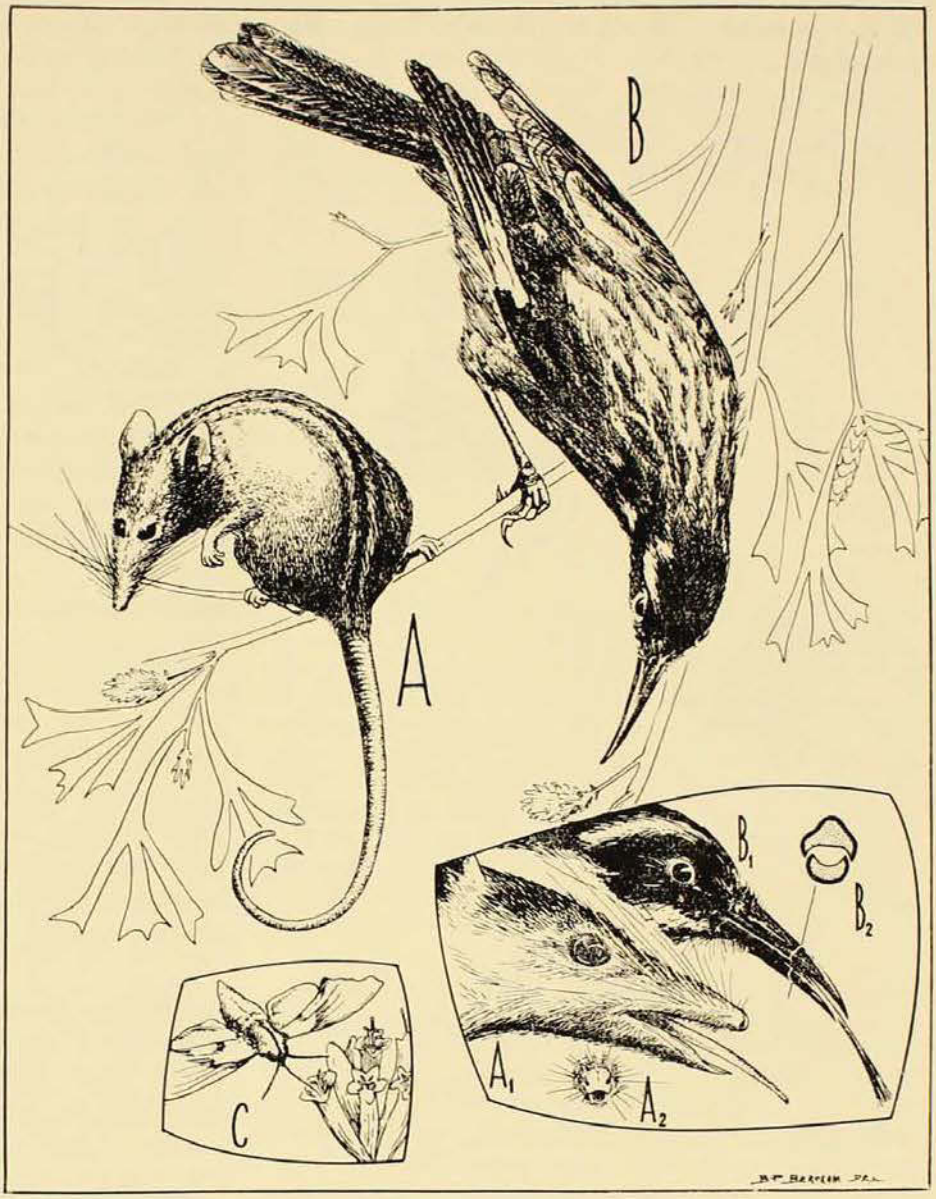


Fig. 4: The Honey Possum or Honey Mouse (*Tarsipes spenserae*) and the New Holland Honeyeater (*Meliornis novaehollandiae*) have similar special adaptations for feeding on nectar and pollen. Note the marsupial's elongated snout and protrusible hairy tongue (A1) and lips modified to form a tube (A2). The honeyeater has a long bill and a protrusible tongue ending in a brush (B1). B2 shows a cross-section of its bill at the point marked. The Hawk Moth (C), like other moths and butterflies, has a long tubular proboscis which it inserts into flowers and through which it sucks up nectar. Though many species of birds have special adaptations for feeding on nectar, few mammals have them to any extent. In the tropical American Bat *Choeronycteris* Microchiroptera) and the Asio-Australian *Macroglossus* (Pteropidae) anatomical modifications similar to those of *Tarsipes* have, however, evolved independently.

eggs within its body until they hatch as tiny frogs, and Nicholl's Toadlet (*Metacrinia nichollsi*), which lives in ants' nests, where, presumably, it enjoys uniform conditions of humidity.

One of the most interesting insects so far recorded from south-western Australia is an ant known as *Nothomyrmecia macrops*, found in the heath country near Esperance in 1934. An authority on Australian ants, Dr. W. L. Brown, of Harvard University, has suggested that it is "the most primitive member of the sub-family Myrmeciinae, which includes the most primitive known of the living and fossil ants." Expressed in everyday language, this simply means that this ant is apparently the only living survivor of a very early kind of "ancestral" ant that has long since died out everywhere else but in this restricted area of Australia.

Almost as great a curiosity is one of the scorpion flies (Mecoptera), *Austromerope poultoni*. It has relatives only in two other parts of the world, Chile and North America.

An interesting point, but at a rather different level, may be mentioned respecting fresh-water Crustacea. Mr. Edgar Riek informs me that although the small Crustacea known as amphipods and phreatoicoids (relatives of the well-known sand fleas and land slaters, respectively) are closely related to those in south-eastern Australia, the crayfish of the south-west are related to those in northern Australia and Cape York. This suggests that the one group must have colonized the south-west from the south-east, and the other down the west coast.

The Isolation Of The South-West, Its Basis

As noted, the flora of the south-west is quite distinctive. Species that are like those in the east, however, are not uncommon.

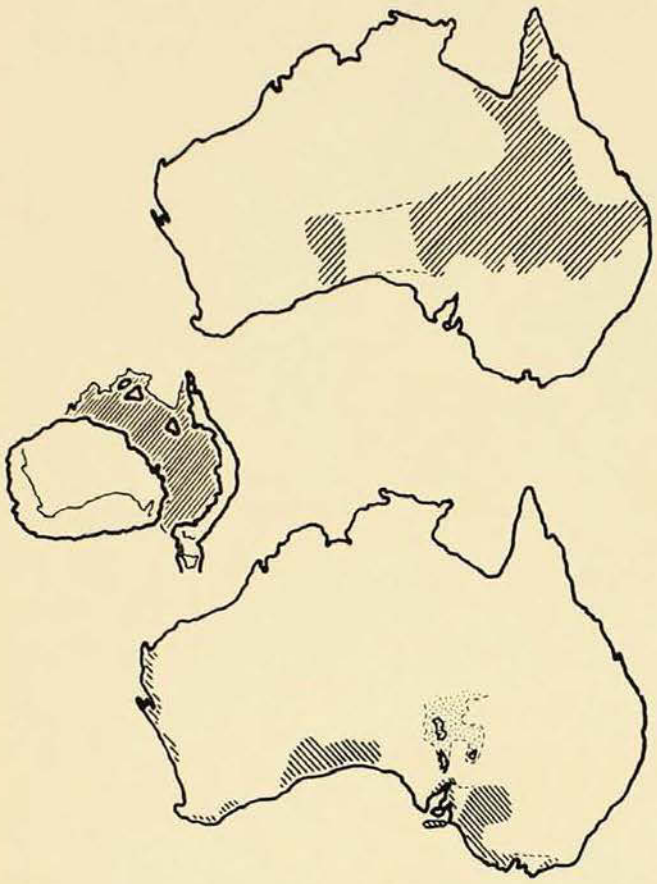


Fig. 5: Early barriers to west-east distribution which apparently were responsible for the origin of the floral distinctness of the south-west: The top map shows the distribution of Cretaceous sea (shaded area) which covered part of Australia and divided it into two or three islands. As flowering plants did not begin to radiate until the late Cretaceous era, however, it is presumed that the much more restricted seas of the Tertiary era (bottom map) were the really significant factor. The soils laid down in the region of the Nullarbor Plain (porous, alkaline limestone and sands) have certainly been the all-important edaphic (soil) barrier since then. (The dotted area in this map, shows the extent of the great freshwater Lake Dieri of late Tertiary and Pleistocene times. Lakes Eyre, Callabonna and Torrens are remnants of this lake). Central left: Wallace's map of the area (shaded) which he supposed was covered by Cretaceous seas. Wallace (1880) was the first to suggest that south-western Australia was once isolated by sea and that this was how it developed such a distinctive flora. The south-western area within the indented line shows where Wallace believed land reached. The larger maps are from Crocker and Wood (1947), with modifications.

Amongst its animals the south-west has a few species that are "relicts" (remnants of groups that have died out everywhere else) and various distinctive types that have, apparently, originated there. The considerable majority, however, is either similar to those in the south-east or is their direct counterparts.

We are now faced with the intriguing question of just how the south-west came to be isolated from the south-east and has remained isolated, so that, though Australia is a continuous land-mass, most of its distinctive plants have not been able to spread to the east, just as later plant arrivals from the north, the descendants of which are prominent in eastern Australia, have not reached south-western Australia.

The answers to these questions are not fully known, but the following can be stated:

• During part of the Cretaceous geological era, which extended from about 127 million years ago to 58 million years ago, and just prior to the great development and spread of the flowering plants, Australia was separated into two parts by sea.

• Subsequently, for part of the Tertiary era, which thereafter extended through to about one million years ago, there were considerable inroads of the sea northwards across today's Nullabor Plain area and in the region of the Murray mouth further east (Fig. 5), an inlet referred to by geologists as the ancient Murravian Gulf.

• Because of this sea, porous limestone was deposited. This weathered to an alkaline soil, quite unsuitable for the growth of the kinds of plants that predominate in south-western Australia. That is to say, there is an "edaphic" (i.e., soil) barrier to the eastward spread of these plants.

• During part of the Tertiary era, and possibly to as recently as a few score thousands of years ago, a great inland freshwater lake embraced the whole of the Lake Eyre, Lake Calabonna and Lake Torrens area. On a couple of occasions this drained into St. Vincent's Gulf. This large lake must also have been a barrier to the spread of plants.

• Dry desert country now extends south to the head of the Great Australian Bight, making it impossible for any plants needing moderate or high rainfall conditions to occur there. This state of affairs has doubtless been operative, off and on, for a long time.

All in all, most animal species are dependent on vegetation and a reasonable rainfall for their livelihood and homes. Distribution, accordingly, is typically restricted to a basic vegetation type or climatic belt. Gaps in vegetation and in rainfall zones isolate animal species, enabling primitive types to survive and leading to the separated populations developing distinctive or different characteristics.

[*Fig. 4 drawn by B. P. Bertram; other illustrations by Wendy Manwaring.*]

Book Review

THE GREAT BARRIER REEF AND ADJACENT ISLES, By Keith Gillett, A.R.P.S., and Frank McNeill, Curator of Crustacea and Coelenterates at the Australian Museum. Coral Press Pty. Ltd., Sydney. PP. i-xiii, 1-194, frontispiece, 161 plates, four charts, text figs. Price £3/10/0.

The Great Barrier Reef is one of the natural wonders of the world. Its 1,200 miles of coral reefs and islands represent the largest structure ever known to have been created by living organisms. To naturalists, especially those whose interests lie in the animals and plants of the sea, whether they be fishes, shells, corals or a host of unusual creatures as well, the Great Barrier Reef is a Mecca to which all wish to make their pilgrimage. To thousands of Australians in recent years, it has been a place of infinite charm and beauty, where delightful holidays have been spent at tourist centres along the reef islands.

At long last an authoritative guide to the places, plants, animals and history of the Barrier Reef has been written, which will be warmly welcomed by all who know the reef's magical attraction. Superbly illustrated by Keith Gillett's photographs, including some 30 coloured plates, the book is packed with details of the life of the countless animals which make up the coral-reef fauna and the birds which inhabit the coral cays. Detailed descriptions of the two great vacation centres, the Capricorn Group (off Gladstone) and the Cumberland Group (off Mackay), will provide the intending visitor with all the information on accommodation and scenic and other attractions that is necessary to the full enjoyment of a Barrier Reef holiday.

Frank McNeill's colleagues had been urging him to write this book for years, for they realized that his unequalled experience of the greater part of the reef, as well as his knowledge of marine fauna, would produce an outstanding work. His many articles on various aspects of the reef are well known to readers of The Australian Museum Magazine, and his literary style is seen to advantage in the text of this book, where scientific facts are explained in non-technical language but without any loss of accuracy which so often mars popular scientific literature.

Accessory chapters by Elizabeth Pope (on the isolated southern coral-reef, Lord Howe Island) and by Keith Gillett (on the technique of marine photography, especially under water) add value to the book, as do the appendices listing the "protected" Barrier Reef islands and the many useful tips for visitors.

The only scientific flaw which has been noted in this book is the use of different scientific names for the same birds in sections by different authors —due, no doubt, to their reliance on different authorities. Thus, the common Wedge-tailed Shearwater of Heron Island, *Puffinus pacificus*, appears in the Lord Howe Island chapter as the Wedge-tailed Petrel, *Thyellodroma pacifica pacifica*. However, this is only a slight inconsistency which can be corrected in the next edition.

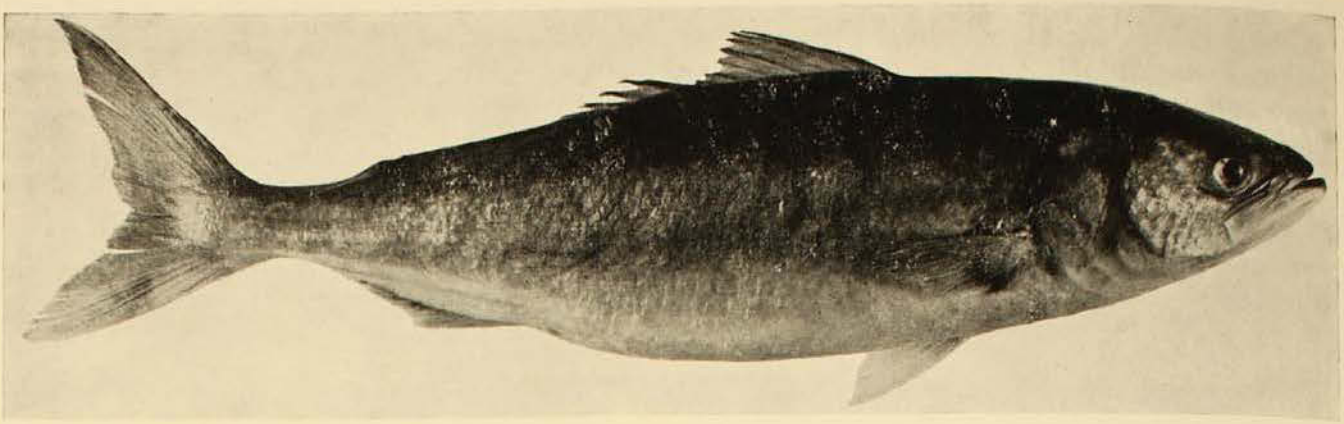
The book is magnificently produced, on high-quality paper.

D. F. McM.

New Curator at Museum

Mr. C. N. Smithers, M.Sc., who has been appointed to the Curatorship of the Department of Entomology at the Australian Museum, commenced duty on February 12.

Mr. Smithers, who comes from Southern Rhodesia, is a graduate of Rhodes University, South Africa, and has had extensive entomological experience. He saw service with the 6th Airborne Division in Normandy during the second World War.



To spawn, Australian salmon (*Arripis trutta*) travel from their nursery and feeding grounds in Bass Strait to south-west Western Australia and southern New South Wales, as shown in the map on the next page.

THE MIGRATIONS OF FISHES

By J. M. THOMSON

Of the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, Sydney

EVERY fisherman, whether the angler seeking sport or the professional seeking his living, wants a good catch, and the best catches, both in number and in size of individual fish, are made during migrations.

Not all fishes migrate, but the majority of commercial fishes do. It is economical to catch those which are schooled up, and the primary reason for schooling in large numbers is to move together along the migration paths to the spawning grounds, ensuring that all the mature fishes arrive together to reproduce. After spawning the fishes subsequently return to their feeding grounds, but usually the schools on the return migration are smaller and do not attract so much notice.

All movement in schools is not migration. Schools, usually of much smaller size, are maintained by many species in the non-migratory season, but these move in a random pattern. Migration is a more-or-less direct and continuous movement from one place to another from which there is a periodic return to the original locality.

The distance fishes migrate varies. Some, after collecting together in schools, travel only a few miles. Others, for instance the tuna of the northern Pacific and the eels of the North Atlantic, travel thousands of miles. Examination of the species undertaking migrations reveals one common factor: all move from the feeding grounds to other places which are more suitable for spawning and from which the young are either passively returned by water currents, or can be guided by environmental factors, towards the adult feeding grounds. The newly-hatched young fishes are poor swimmers, a fact which places them at the mercy of the drift of water currents.

In the evolutionary development of the migratory fishes a pattern has been laid down. It is such that when the gonads near ripeness the fish is stimulated to swim from the feeding grounds against the prevailing water currents until a suitable spawning ground is reached. From there it is only a matter of time for the young to drift more or less passively back to the feeding grounds, where the most active spent fishes will have preceded them. The eggs of many species are also pelagic (free-floating), so that even before hatching the return journey to the feeding grounds will have begun.

In some oceanic areas more than one current may reach a particular locality, one waxing while the other wanes.

An interesting example of this and of the effect it can have on the fishes is shown in the Bass Strait area. Bass Strait, particularly along the northern shores of Tasmania, is a fine nursery ground for the Australian salmon (not allied to the northern hemisphere salmon), but they do not spawn there. Two principal water currents influence Bass Strait, one coming from the west and one from the north-east. The developing salmon, in its search against the current for a spawning ground, has two choices, either to swim west or to swim north. In fact some go one way and some the other. Those going west spawn off south-west Western Australia, and those moving north spawn off southern New South Wales.

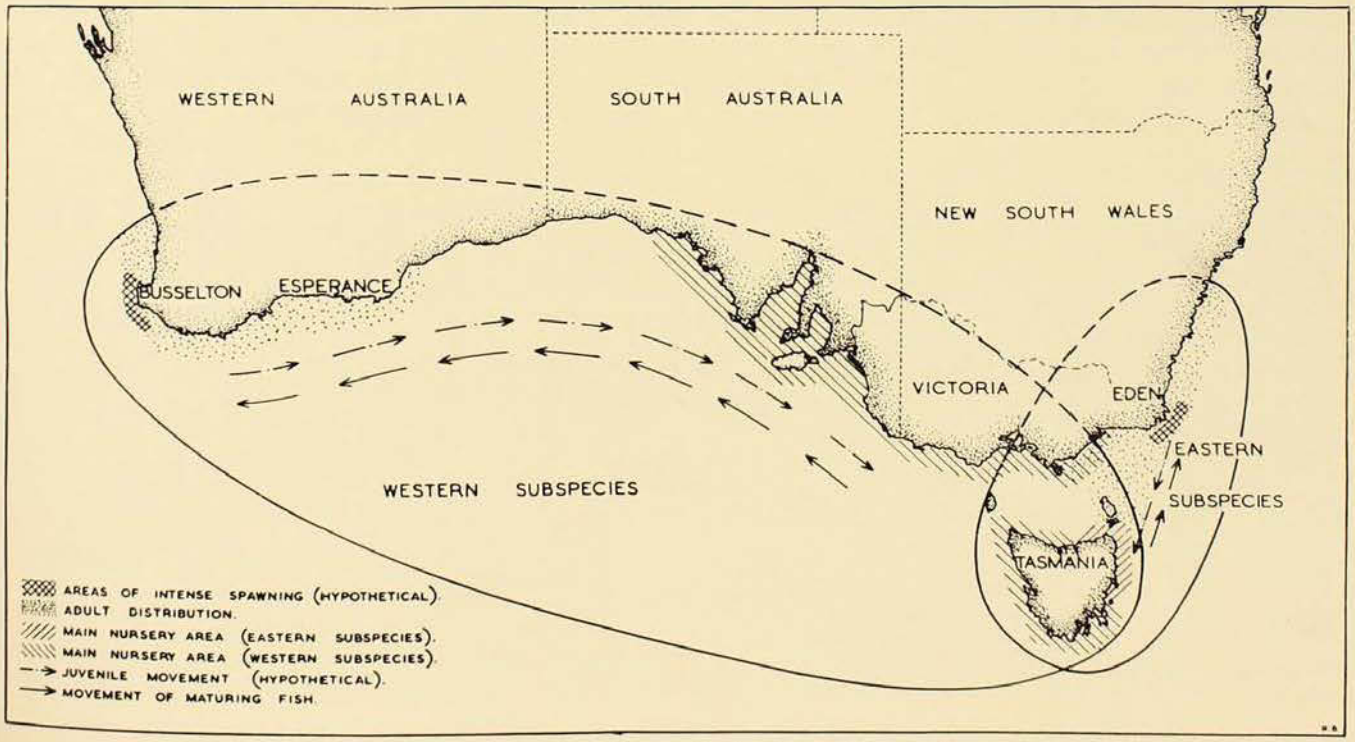
There are thus two widely separated spawning grounds, providing a reproductive isolation which potentially could allow evolutionary divergence—and this has happened. There are small significant anatomical differences between the western and eastern sub-species, such as a distinct difference in the number of gill rakers (the "comb" structure on the gills which sieves out the food) correlated with diet. The western sub-species, with fewer rakers, has a predominantly fish diet. The eastern sub-species, with more gill rakers, feeds mainly on a kind of small oceanic shrimp called a euphausiid. The western sub-species grows at almost twice the rate of the eastern, and the two groups spawn at different times.

The salmon also occurs in New Zealand, where it is called "Kahawai." It is almost identical with the eastern sub-species, and it is possible that interchange continually occurs across the Tasman, for the southerly-drifting current on the east coast swerves eastward from the level of Bass Strait.

Sea Mullet's Migration

The Sea Mullet is another Australian fish which makes a definite migration against the currents. In late summer a movement to the north starts in the south, and this migration gradually goes further and further north until the pattern is finished in May or June at the northern limits, Shark Bay in Western Australia and the central Queensland east coast.

Probably few, if any, of the mullet from as far south as Victoria go right to Queensland to spawn. The spawning grounds are not known, but recent discoveries concerning what is believed to be the same species in the Black Sea and the Gulf of Mexico indicate that the fishes probably spawn over



The spawning migrations of the Australian salmon.

deep water, though spawning itself occurs in the surface layers. But marked fishes have been taken only from the river where they were tagged or from rivers or beaches to the north, and the more seasons they have been free the further north are the travelled fishes taken. However, others, which must have spawned between tagging and recapture, may be retaken in the same river system after many years.

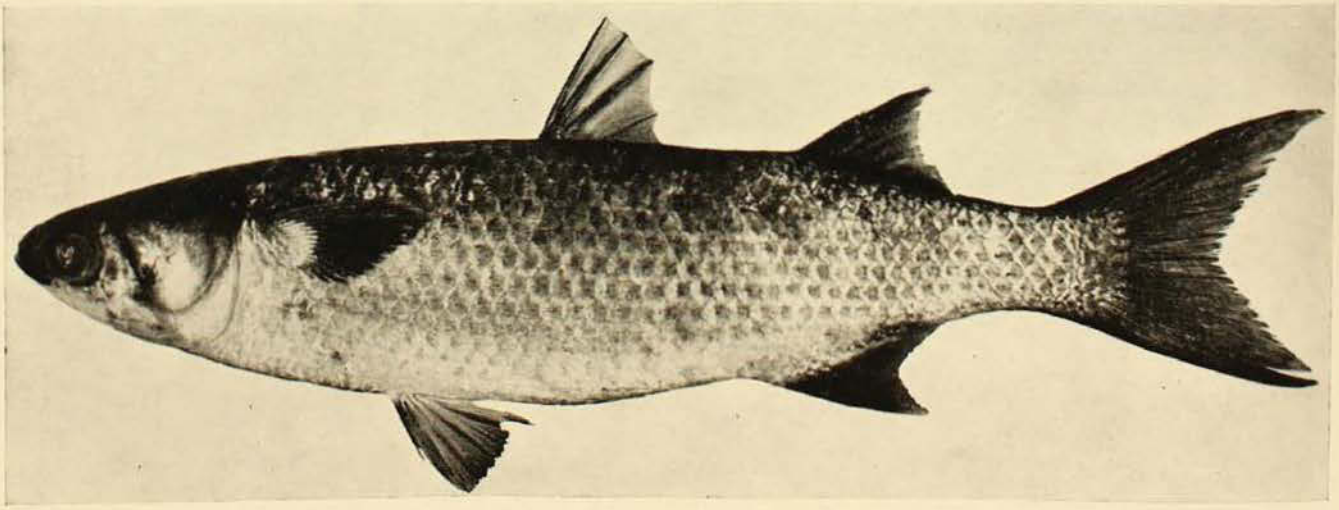
The probable explanation is that the migration to the north is an inherited pattern of behaviour that permits the rivers and coastal lakes from which the parents have come to be re-populated by arrival of the small fishes drifting down on the current. There are probably many spawning areas along the coast; some fishes may move further than others before spawning, and individual differences in physical strength and in chance movements determine whether the spent fish drifts back to the river from which it came or moves into another river further to the north.

Both salmon and mullet have pelagic eggs. Other fishes have demersal eggs—that is, eggs resting on, or attached to, the bottom. An example of demersal eggs is provided by the well-known herring of Europe, the eggs of which are attached by a glutinous material to sand grains on the sea floor. But again an up-current migration occurs, and subsequently the feebly-moving, newly-hatched herring drift on the current.

Catadromous Fishes

Some fishes are termed catadromous; they are fish which feed in the fresh waters of rivers and lakes but return to the sea to spawn. The Sea Mullet are partly catadromous because many of them do make their way up to the fresh water, but this phase of their life is not believed to be obligatory. However, in some fishes it may be. The eel, for instance, spends the greater part of its life feeding in fresh waters before it returns to spawning grounds in the sea where, its life's mission of continuing the species accomplished, it dies. The common eel of the North Atlantic is believed by some to display a pattern somewhat the reverse of that shown by the Australian salmon. The eels from two sources, Europe and North America, spawn in the same area, the Sargasso Sea, and the larvae drift on the two arms of the gulf current, one north to the east coast of America, the other north-east to Europe. Reaching land, the eels move into the rivers. After some years, it is believed, they come down-river and, heading against the currents, return to the family spawning ground.

However, some recent critics have suggested that only parents from North America actually reach the Sargasso Sea to spawn. Early workers regarded the eel of North America as a different species from that of Europe, but at least some authorities now believe the differences are due solely



More Sea Mullet (*Mugil cephalus*) are caught in Australian waters than any other species of fish. The biggest catches are made during spawning migrations.

to the different lengths of larval life and the different temperatures experienced by the two sets of larvae after leaving the Sargasso Sea. The American eels have a shorter distance to travel and are in warmer water. In many fishes it has been shown that difference in the number of certain features, such as vertebrae and fin rays, results from differing temperatures experienced in early development. These same critics believe the dispersal of the eels around the whole European coast and the distance involved in the journey back to the Sargasso Sea, plus the more or less degenerate state of the grown eels when they leave the European rivers, indicate that no migration back to the Sargasso Sea is possible.

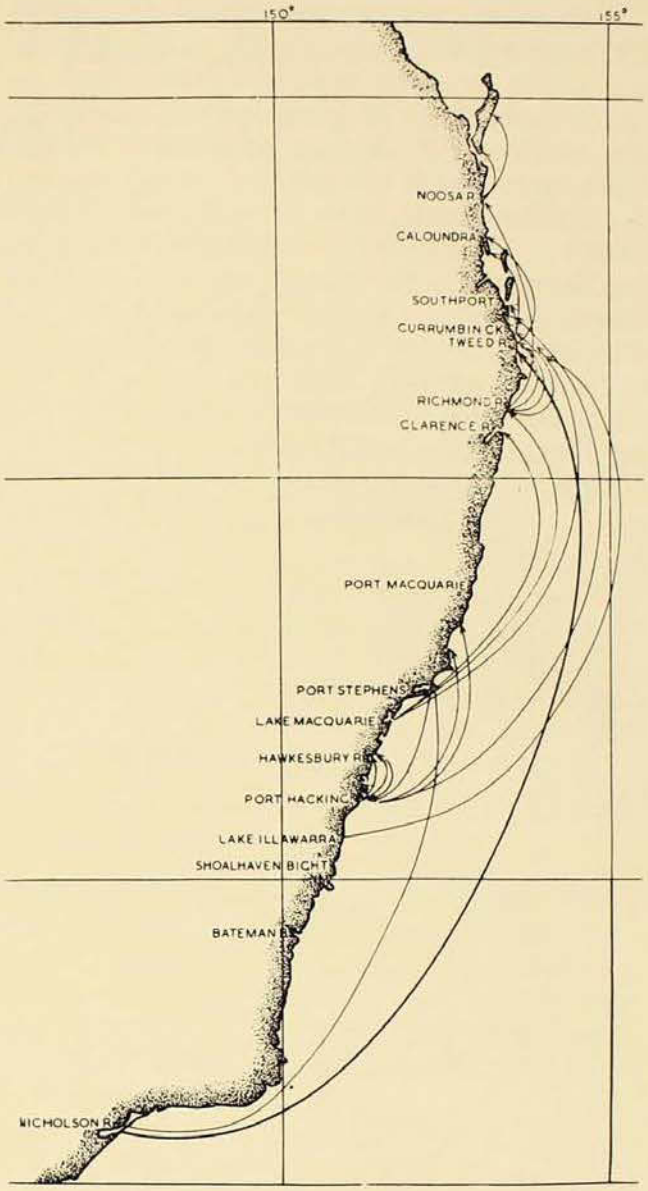
Anadromous Fishes

In contrast to the catadromous fishes are the anadromous ones, which spend their life at sea in the feeding phase and breed in fresh water.

Two small Australian fishes do this—the whitebait of Tasmania and the eel-gudgeons of New South Wales. The whitebait are believed to live only for 12 months and to die after spawning. The Australian bass, or estuary perch, also runs up from the sea to spawn, but possibly does so in brackish, rather than fresh, water.

Much better-known are the famous anadromous salmons of the northern hemisphere. Although they live for a greater span of years, some of them, the Pacific salmon of several species, die after they spawn in the headwaters of the rivers. The Atlantic salmon, however, may spawn several times. The young are relatively safe from predators in the fresh water. Sooner or later they head or drift downstream to the oceanic feeding grounds, where they may range for hundreds of miles.

Many other fishes are known to migrate, but always the pattern is the same—a movement to a spawning ground from which the young will drift to a suitable nursery area, and a return of the spent fishes in smaller schools from the spawning area to the feeding area



The spawning migration of Sea Mullet up the New South Wales and Queensland coasts, as shown by the recapture of tagged fish.

Some migrations may be no more than a schooling of fishes scattered in a river or an estuary, with a movement to the mouth of the estuary, where spawning occurs. This is almost always timed at slack low water, usually at night. The eggs are pelagic, and the rising tide carries them well into the estuary. They hatch within a few hours. In the estuary the feeble movement of the newly-hatched fry is sufficient to get at least some to the safety of weed banks or lagoons, and the others may well return again on the next tide. Such small-scale migrations also occur with some species in fresh-water lakes.

Large-scale movements, which are not so clear-cut but may be regarded as migrations, are made by some elasmobranchs, such as the School Sharks of south-eastern Australia. By marking or tagging specimens, large-scale movements throughout south-eastern Australian waters have been shown. These may be predominantly feeding movements, but the females do migrate into the estuaries and shallow bays to "pup"—that is, to produce the young alive—for in this species, as in several sharks, the eggs hatch in the mother's body and the young are well-developed before being born.

Scientists can track the paths of migrations fairly well by marking the fishes—by attaching a tag or, in the case of true salmon, perhaps by removing a fin. Even then the movements of some species are less known than others, for return of the tags depends on the fishes being recaptured; if they move on their migration to an unfished or lightly fished area they will escape recapture.

It is relatively easy to map out the migration paths of fishes. But the knowledge gained poses other problems: How do the migratory fishes find their way, sometimes across hundreds of miles of open water? Why do they react to certain outside stimuli, such as currents, differently when spawning time comes near? What starts them schooling, and what triggers off the migration?

Doubtless the answers lie partly in the still mysterious field of the endocrine glands and partly in certain sense organs which are unique to fishes, such as the so-called lateral line, the function of which is little understood. These and other anatomical and physiological functions of the fishes are coming under the scrutiny of the scientist in his never-ending endeavour to advance the frontiers of knowledge.

[*Photos in this article are by courtesy of the C.S.I.R.O. Division of Fisheries and Oceanography*].

FOSSIL INSECT RESEARCH

As might be expected, insects are seldom preserved as fossils. Consequently, strata containing fossil insects are of great scientific importance.

It is of interest that some of the best fossil insect-bearing beds are to be found in Australia. Of the three notable outcrops one is in Queensland, near Ipswich, and the other two are in New South Wales. The Queensland beds are of Triassic age, while those in New South Wales belong to the Triassic (Brookvale) beds and Upper Permian (Warner's Bay) periods. Some of the most magnificent fossil insects ever discovered anywhere in the world have been found at Brookvale, but unfortunately the quarries from which they came are now worked out.

The Permian beds at Warner's Bay outcrop on the surface of the ground over an extensive area. These Permian fossils are the remains of insects which lived in Australia some two hundred million years ago. While many have already been found at Warner's Bay and their study has done much to add to the knowledge of the evolution of insects, only a small proportion of those presumably contained in the same strata can yet have been brought to light.

Area Gazetted As Reserve

To ensure that the beds shall be available for investigation at any time in the future, some 41 acres in the Warner's Bay neighbourhood were recently gazetted as a Fossil Insect Reserve.

The mapping of these beds was done by Mr. O. Le M. Knight, an Honorary Associate of the Museum, who has presented to the Museum abundant fossil insect material which he has collected.

THYLACOLEO, THE EXTINCT MARSUPIAL LION

By B. DAILY
Curator of Fossils and Minerals, South Australian Museum

THYLACOLEO, the Marsupial or Pouched Lion, an extinct Pleistocene marsupial of the Australian continent, is more puzzling and has aroused more curiosity as to probable food habits and affinities than has any other fossil marsupial.

In 1859, the renowned vertebrate palaeontologist, Sir Richard Owen, described and named the creature from skull remains found near Camperdown, Victoria, although its earliest remains were found in the Wellington Caves, New South Wales, some 30 years earlier. Professor Owen called this new species *Thylacoleo carnifex*, meaning the flesh-eating marsupial lion.

Remains of *Thylacoleo* have been found in cave-earth and fresh-water deposits in every Australian State except the Northern Territory. Strange as it may seem, no irrefutable post-cranial skeletal remains were ever found in direct association with its skull until 1956. Consequently, much of the extensive literature pertaining to *Thylacoleo* deals with the morphology of its skull and deductions on its possible food habits based on its peculiar dentition. The molars are small and reduced in number (one upper and two lower on each side), and there are unusually large sectorial third premolars in both the upper and lower jaws, each of which is equipped with large tusk-like first incisors. The remaining teeth are exceedingly small and virtually functionless.

From studies based on the skull and teeth, several workers have claimed that *Thylacoleo* was the largest of the Australian carnivores of the Pleistocene period. Indeed, Professor Owen concluded in 1877, that, from the size and form of the third premolars, especially the upper one, "we may infer that it was one of the fellest and most destructive of predatory beasts."

But not all have shared this view. Some have considered *Thylacoleo* a harmless herbivore, others that it was omnivorous in habit or, peculiarly enough, that it was specialized to the point where its food consisted of eggs, or even melons. (A fuller discussion on food habits is given in an article by E. D. Gill, Vict. Nat., Vol. 71, No. 2, 1954.)

Circled is the large hooded terminal bone of the first digit of the Marsupial Lion's right forefoot in juxtaposition with the other digits. These were found during excavations in a quarry at Naracoorte, South Australia, in March, 1959.

Photo.—Author.

Such diverse opinions as these showed that, if we wanted a greater understanding of this odd animal, more than just its skull was needed on which to base conclusions. This had been pointed out very clearly by various students, but all efforts to obtain a complete or near-complete skeleton had proved fruitless.

Important Discovery

Then, in December, 1956, Mr. Amos James, proprietor of the Naracoorte Quarry, reported some fossil bones on the floor of a cave after blasting had removed part of the quarry face. Mr. James' subsequent report to the South Australian Museum was so encouraging that immediate arrangements were made for Norman B. Tindale, Curator of Anthropology, and Paul F. Lawson, preparator, to examine the site.

What they found was no familiar skeleton. Partly embedded in an unconsolidated calcareous sandy layer on the floor of a small cave, about 12 ft. above the quarry floor, was an almost complete skeleton of the Marsupial Lion. The bones, though extremely fragile, were well preserved.

When first discovered, the skull had been complete, undeformed and largely protruding from the surrounding sediment overhanging the quarry face. As inclement weather threatened the safety of the skeleton in such an exposed position, Mr. James covered it with a hessian bag, hoping to protect it. Unfortunately, the rain-soaked bag proved too heavy, and the skull, crushed beneath its weight, tumbled down amongst the talus against the quarry face.

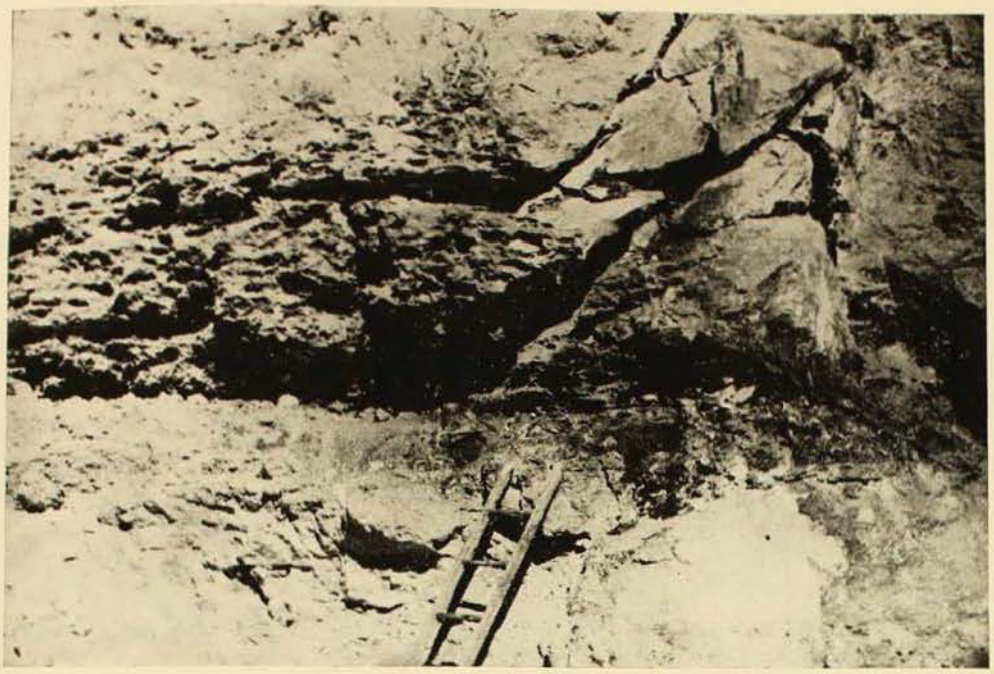
Mr. Tindale and Mr. Lawson collected all fragments from the talus, and Mr. Lawson, perched on a ladder, then set about the difficult task of excavating the remainder of the skeleton from its precarious position. This was successfully accomplished. (In addition to the *Thylacoleo* remains, bones of wallabies, kangaroos and rodents were uncovered during these excavations.)

Subsequent investigations at James' quarry carried out by Mr. Tindale and the author in mid-February, 1957, added a few more bones of *Thylacoleo* to the original collection. They, together with other marsupial remains, mainly those of kangaroos, were found within 6 ft. of the initial discovery. Investigations showed that the cave in which the remains were found was formerly connected by narrow passages and solution channels to three other small caves in the quarry, all on the same level. These passages had developed in the almost-flat bedded Naracoorte Limestone, a differentially indurated marine limestone deposited during the mid-Tertiary period about 25 to 30 million years ago. The oldest cave fill, a thin yellow to brown coloured clay stained with black oxides of manganese and almost devoid of bone remains, was deposited during a wet phase of the cave's history, and represents the residue after solution of the Naracoorte Limestone by carbonated ground water. A decorative phase followed, as is shown by the abundant flowstone capping these clays in some passages and by the stalactites both hanging from the roofs of small chambers and incorporated within the sediments in which the fossil bones were preserved.

Bones Buried In Sand And Rubble

The Marsupial Lion died above the clay layer, and its bones were covered by an uncemented layer of calcareous sands and rubble. Part of this sediment is due to the fretting of the Naracoorte Limestone, a process still operative in part of the cave system. A vivid example of the process was seen during this visit in a cave which had been opened up by quarrying operations. This recently-developed cavern, extending from the level of the quarry floor down to the water-table, had been secondarily formed by roof-plucking of the Naracoorte Limestone. Huge blocks of a soft white bryozoal limestone, stacked on top of each other, were covered with thick deposits of fine material which had fretted from the roof. Articles left in this cave at this time were found to be covered by a thin deposit of the same material on a subsequent visit in 1959. The remainder of the sediments consisted of quartz sands derived from the breakdown of the loosely-cemented Pleistocene marine sands which cap the Naracoorte Limestone.

The picture that emerged from these investigations was that, at some time in the past, native animals fortuitously found their way into these small galleries, where they



The site of the first discovery of a Marsupial Lion's skeleton in a quarry at Naracoorte, South Australia, in 1956.

Photo.—Paul F. Lawson.

died from starvation, injury or some other cause. Their bones remained where they died or were slightly disturbed by the wanderings of other animals or by occasional blocks of rock dropping from the roof. Partial or complete interment was effected as described above.

Here now, for the first time, were definite bones of *Thylacoleo* other than those of its skull. Prior to this discovery, bones allegedly belonging to the Marsupial Lion had been drawn and described by some workers, notably Professor Owen and C. W. De Vis, a former Director of the Queensland Museum. The new find confirmed many of the views of these comparative anatomists. This is a tribute to their clever deductions, for there are few people who could study a bone or bone fragment of a formerly unknown type and then correctly deduce that it belonged to an animal only known to science by its skull.

Further Discoveries

In June, 1958, a chance discovery of a complete skull of a young *Thylacoleo* was made by Mr. Robert T. Sexton, of the Cave Exploration Group (South Australia), in the red earth fill of the Curramulka "Town" Cave. The bone was encased in red clay cemented with calcium carbonate, and on previous trips had been unwittingly used as a foothold to climb a low rise over fallen roof blocks at the entrance to the "Bedroom-Chamber" Cave. This is a veritable graveyard, for its walls of stratified clays are studded with bones, large and small. Abundant charcoal within the cave-fill may enable its age to be determined by the Carbon 14 method.

A partial and articulated skeleton of another *Thylacoleo* was discovered in windblown sand deposits at Lake Menindee, western New South Wales, in August, 1958, by Professor R. A. Stirton and Richard H. Tedford, both of the Department of Palaeontology, University of California. It is of interest that these remains are directly associated with evidence of an Aboriginal occupation of the site, dated by Carbon 14 as having occurred approximately between 6,470 and 6,670 years ago. This is the most recent date yet determined for *Thylacoleo's* survival, but it may have persisted to a much more recent date before final extinction.

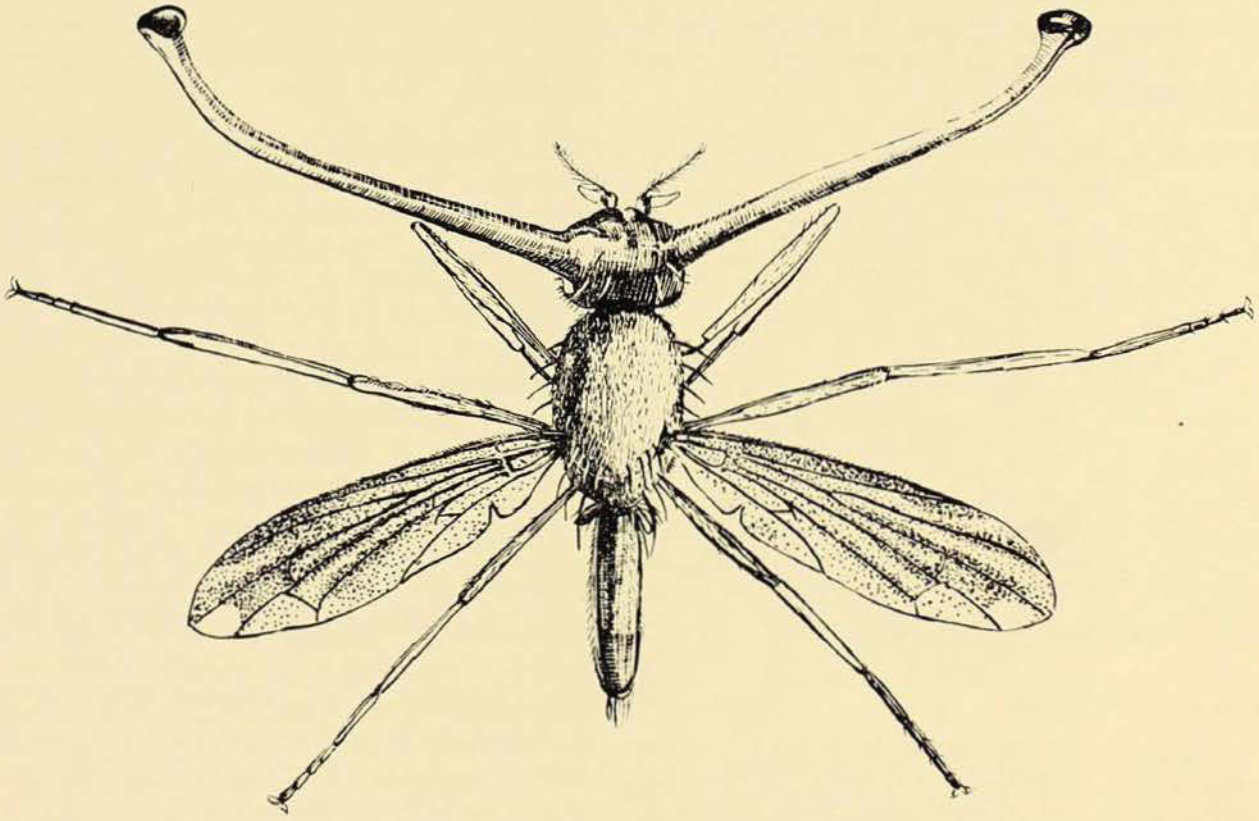
The latest finds of *Thylacoleo* reported to the South Australian Museum were made in March, 1959. The first was made by Mr. James at his Naracoorte Quarry and the other during the exploration of a newly-found passage in the "Cathedral" Cave, Naracoorte, by members of the Cave Exploration Group (South Australia).

The quarry specimen was revealed by blasting, but most of it had been removed during quarrying before its discovery. Mr.

Peter F. Aitken, Assistant Curator of Insects at the South Australian Museum, and the author visited the site and collected the bones of two partly-articulated fore-feet, fore-leg bones and other bones, including teeth, lying on and partly within a yellow-brown clay fill on a small ledge forming the back part of a narrow passage. The animal had died where found, with the fore-legs poking into the furthest corner of the cave. The site was continuous with, or on, the same gallery level as that of the first specimen, taken in 1956-1957. The fore-feet are particularly interesting, with five curved and hooded terminal phalanges which in life supported claws. The terminal phalanx of the first digit, more than 1 in. in length, far exceeds in size the remaining four, which show little gradation in size.

The "Cathedral" Cave material consisted of both fore and hind foot bones of the Marsupial Lion, in association with its teeth, and bones of other mammals, which were collected in an inch-thick layer of brown sand on the floor of a passage just wide enough to allow a man to squeeze through. Nothing definite can be established about the ages of all of the Naracoorte specimens. Geological evidence indicates that in all probability they are either late Pleistocene or early Recent in age.

Professor Stirton and Richard Tedford are now undertaking a joint study of all the skeletal material found in South Australia since 1956. In a letter to the author shortly after the collections arrived in California, Richard Tedford wrote: "The limb elements, and particularly the feet, are presently posing more questions than they seem to answer. It's going to be exciting work deciphering the affinities and possible habits of this animal".



The remarkable fly pictured above is a male of the genus *Laglaisia*, which, with a female, was recently sent to the Australian Museum by Mr. R. T. Simon Thomas, of Hollandia, Dutch New Guinea. These are the first *Laglaisia* flies in the Museum's collection. In the male the eyes are on long curved stalks, each of which is longer than the whole body. The shape of the head is thus suggestive of the handle-bars of a bicycle. The width of the head from eye to eye is 22mm. (nearly 1 in.). The head and body length is 9 mm. The head of the female is of normal shape and size. (Drawn by F. J. Beeman.)

Gall and Predaceous Wasps

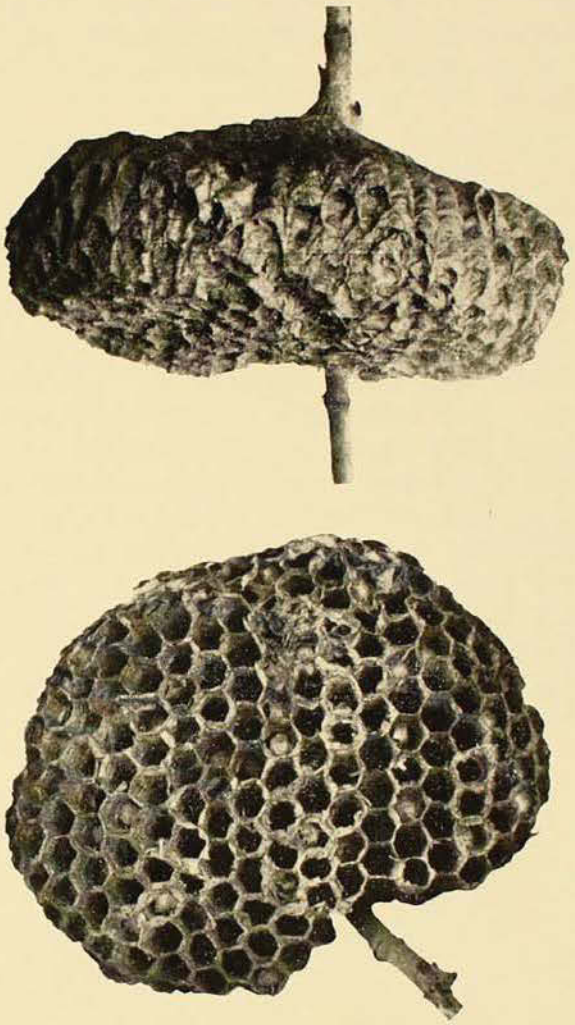
By DAVID K. McALPINE

[*This is a second article on Wasps by Mr. McAlpine, the first having been published in the issue of March,* 1958.]

THE true Gall Wasps of the family Cynipidae are very poorly represented in Australia compared with countries in the Northern Hemisphere. They are nevertheless of much interest.

These wasps resemble some of the parasitic kinds in their small size and reduced venation of the wings. Their eggs are inserted into the stems and leaves of plants. Like a number of other kinds of insects the larva makes the plant tissue, which surrounds it, grow into a bulbous swelling called a gall. The gall, which protects the larva from many, but not all, enemies also provides food from its succulent interior. The mechanism which causes the growth of the gall is not well understood, but may be a combination of the physical effect of the larva eating the tissues together with the production by the larva of chemicals which stimulate plant growth. When fully fed the larva pupates within the gall, and the fully grown wasp cuts its way out on emergence from the pupa.

In some species of gall wasps no males have been seen and the eggs are able to develop without fertilization. Males are comparatively rare in some other kinds and may only appear at certain times of the year. The adults of a British species (*Neuroterus lenticularis*) provide an example of the latter type. The adults emerge in the spring after spending the winter in the pupal stage within the galls. These galls are lenticular in shape and attached to the lower surface of oak leaves. No males are present in this generation, the eggs of which are laid, without prior fertilization, deep down in the new shoots and catkins of the oak. The larvae from these eggs produce spherical galls and in these both male and female wasps develop. These emerge during the summer and were once thought to be a distinct species, as both the fully grown females and the galls are of different appearance from those of the previous generation. However, the larvae from their eggs produce once more the flattened, lenticular winter galls and the annual cycle is completed.



The nest of a Paper-nest Wasp (*Polistes humilis*), viewed from the side (top picture) and from below. Approximately natural size.

Photo.—G. C. Clutton.

Most of the Australian gall-making wasps do not belong to the same family as the true gall wasps (Cynipidae) but are more closely related to parasitic kinds. Among the most frequently affected Australian plants are wattles and eucalypts.

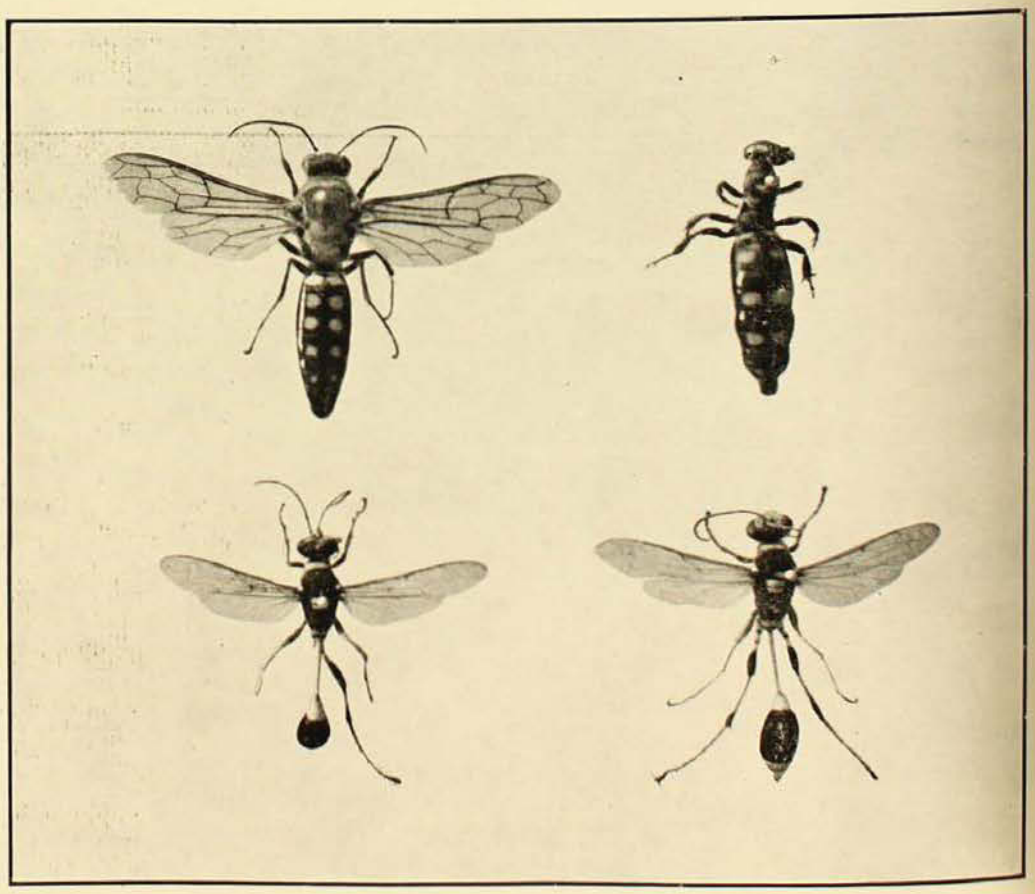
Probably the most interesting of all gall-makers are the Fig Wasps (Family Agaontidae) upon which the pollination of figs is dependent. The females are very small black wasps with transparent wings and a peculiar elongate head. The males, in contrast, are pale yellowish-brown wingless wasps with short heads; the middle pair of legs is weak and slender or sometimes absent.

The species responsible for the pollination of the edible Smyrna fig closely resembles in its habits those that pollinate the native Moreton Bay fig. Only female flowers are contained in the receptacles (the so-called fruit) of the Smyrna fig. These do not ripen unless fertilized by pollen from another variety of fig called the caprifig. The female wasp, after entering a young receptacle of the caprifig, lays its eggs on some of the tiny flowers, which are converted into small galls by the larvae. The male wasps emerge first and, after opening the female galls with their strong mandibles, fertilize the females and die without leaving the fig receptacle. The females emerge from the galls and, before finding their way out of the opening at the end of the receptacle, pick up pollen grains which adhere to the legs and body. They then fly to another receptacle where they pollinate the female flowers and lay their eggs. However, they frequently enter the receptacles of the Smyrna figs, if they are growing nearby, and though they pollinate the flowers they are unable to find a suitable place to lay their eggs. Thus the fruit ripen without being infested by wasp larvae, which would render them unsuitable for human consumption.

At least two species of fig wasps pollinate the Moreton Bay Fig. Their lives are simplified by the fact that all the receptacles of this tree are suitable for the deposition of eggs and development of the larvae. It is, however, necessary for the females to cut their way through the receptacles as there is no opening at the end by which they may enter and depart.

Citrus Gall Wasp

The Citrus Gall Wasp (*Eurytoma fellis*) belongs to yet another family (Eurytomidae). This is a native Australian species, which originally attacked the native citrus trees but has readily taken to cultivated



Above: Male and wingless female Thynnid Wasps (*Hemithynnus apterus*). They are black and brown, with yellow spots. Below: Specimens of a Sphecid Wasp (*Sceliphron laetum*). Approximately natural size.

Photo.—
G. C. Clutton.

kinds. It appears to be spreading southwards, and has only become a pest in the Sydney suburbs in the last few years. Eggs are usually laid between the bark and wood of the smaller branches of citrus trees in spring. The larvae which hatch from them produce noticeable galls in a few months, and these swellings may extend some distance along the stems. The adult wasps, which are small black insects about a tenth of an inch long, emerge from the galls during the next spring. The insect is controlled by cutting and burning the affected parts of the trees during late autumn and winter.

Predaceous Wasps

It is these wasps that are so familiar because of the painful stings inflicted by the modified ovipositor of the females. As the males lack an ovipositor they cannot sting.

The Thynnid Wasps (Family Thynnidae) occur only in Australia and South America, about five hundred Australian species having been recorded. The females are wingless and usually smaller than the males, which carry them about during the nuptial flight in summer. After mating, the female burrows into the soil and, when it finds a suitable victim (usually the larva of a scarab beetle), paralyses it with the sting, lays an egg on it and proceeds to search for further prey. The larva eats the food thus provided, and, when fully fed, pupates inside a cocoon in the soil. During the next spring or summer the adult emerges. One species of thynnid wasp (*Diamma bicolor*) is peculiar in having the female (length $\frac{3}{4}$ in.) much larger than the male, which is therefore incapable of carrying its mate in flight. The shining blue-black female selects mole crickets as its prey. The male is dull black and rarely seen.

The Sand Wasps (Family Pompilidae) are burrowing wasps that stock their burrows with paralysed spiders. Through their agility these wasps are usually able to avoid the fangs of spiders and insert their sting in a soft part of a spider's body. Sometimes the wasp's attack is followed by a terrific tussle but almost invariably the wasp wins. *Salius bicolor*, an orange and black wasp measuring over 1 in. in length, is common in eastern Australia. It has been observed dragging the limp body of a large huntsman spider to its nest. Still larger species occur in some countries. One species is able to overcome the large American "tarantula".

Kills Cicadas

The Australian Cicada Killer Wasp (*Exeirus lateritus*) bears a remarkable resemblance to the sand wasp *Salius bicolor* though it is not related and belongs to the much smaller family Stizidae. It stocks its very deep burrow with large cicadas.

Among the numerous other kinds of burrowing wasps those of the family Bembecidae are of interest because their habits approach, to some extent, those of the social wasps. Most of the species are stout grey and black wasps about $\frac{1}{2}$ to $\frac{3}{4}$ in. long with a very short waist. The burrows are frequently grouped together in a colony, yet the individual wasps work separately and independently. The food of the larva consists of flies and, unlike those forms already mentioned which abandon the nest after laying the eggs and leaving a food supply, the adults continue to feed the larvae on fresh flies until they pupate. The degree of parental care is thus comparable with that found in the social paper-nest wasps.

Two specimens of a Paper-nest Wasp (*Polistes humilis*), about one-and-a-half times natural size. This wasp is reddish-brown and black.

Photo.—G. C. Clutton.

Related to the above are the Sphecid Wasps (Family Sphecidae) which have a longer waist than the bembecids. Though many of these are burrowing forms, the most familiar of Australian species, *Sceliphron laetum*, is not. This yellow and black insect, which measures about 1 in. long and has a remarkably long, slender waist or petiole, builds its mud nests in such sheltered spots as the corners of rooms and outhouses. The author has known them to build in disused tobacco pipes. The nests usually contain several cells in which small spiders are placed.

Of similar habits to this species are the Mason Wasps (Family Vespidae, sub-family Eumeninae). They differ in their preference for caterpillars but construct similar mud nests. Like the sphecid wasps they exhibit no parental care beyond the preparation and provisioning of the cells before egg-laying.

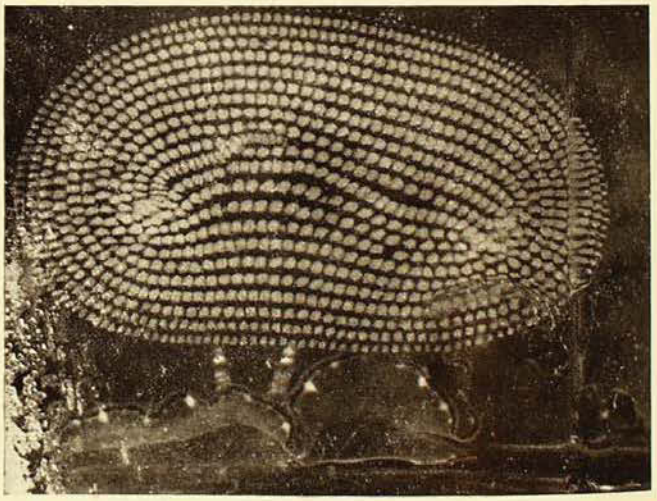
The family Vespidae also includes the Social or Paper-nest Wasps, which live in colonies and feed their larvae till they pupate. The nests are many-celled to house the larger number of larvae in each colony. A grey, paper-like substance produced by masticating wood is used for the construction of the regular hexagonal cells, which resemble those of the honey bee in appearance.

Nests Two Feet Long

The typical social wasps of the Northern Hemisphere (Subfamily Vespinae) construct spherical nests, completely enclosed except for the small entrance, with several tiers of cells within. Nests of this kind are not made by Australian species. The largest nests made by Australian social wasps are those of the small wasp *Ropalidia cabeti*. They consist of unprotected combs forming an irregular mass up to 2 ft. long attached to a tree trunk. A closely related species, *Ropalidia gregaria*, builds much smaller nests, under 3 in. in length, consisting of two rows of vertical cells which may be likened to organ pipes. As compared with other social wasps these two species, representing the subfamily Ropalidiinae, have a simple social organization, as there appears to be no differentiation among the females into queen and workers. They are most common in Queensland.

On account of their abundance in temperate regions two species of *Polistes* (*P. humilis* and *P. variabilis*) are the best known of Australian social wasps. They belong to a third subfamily of the Vespidae, the Polistinae. There is no covering around the cells, which are arranged in a single layer facing the ground to form a rounded nest. This is suspended by a central stalk from a shrub or other suitable support. A queen which survives the winter begins to build in the spring and, when the first few cells are formed, it lays eggs. It later feeds the larvae which hatch from them. When the first few workers emerge from the cells, the queen is relieved of all tasks except that of egg laying. The workers, as in ants and social bees, are sterile females which enlarge the nest, feed the larvae and protect the colony by stinging intruders. Sometimes a nest is used and enlarged season after season until it may attain a diameter of up to 10 in.

FLATWORM EGGS



This egg-mass was laid on the side of a small jam jar by a captive polyclad flat-worm (seen just below the egg-mass), which was found under a rock at Long Reef, near Sydney, in March, 1959. This worm is new to the Australian Museum's collections. A second specimen of the same species was collected at Long Reef later that summer, and it also deposited the same kind of characteristic egg-string. Another species, in a separate dish, laid eggs in an entirely different pattern. This is the first local identification of polyclad egg-strings. The specimens, data and photo were supplied by Mr. A. Healy.