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FRONT COVER: Shown with its insect prey is *Drosera spathulata*, a Sundew common in swampy or damp places on the east coast of Australia between the Great Dividing Range and the sea, and occasionally found in wet heaths in Tasmania. This species of carnivorous plant also occurs throughout Asia and in the Philippines, Borneo and New Zealand. (Photo: S. Jacobs). See the article on Australian carnivorous plants on page 1.

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AUSTRALIAN CARNIVOROUS PLANTS

By **N.S.LANDER**

Over the last 100 years a certain "carnivorous-plant-mindedness" has developed in the general public, encouraged by stories of fabulous man-eating trees told in popular magazines and newspapers. Such accounts are invariably accompanied by gruesome illustrations which depict flowers as diabolical traps. More often than not the scenes of these stories are set on mysterious faraway islands, in the depths of tropical jungles or even on planets other than our own. While these blood-curdling tales are intended for titillation rather than instruction, they do contain some measure of truth: there are plants on earth capable in miniature of much that writers of fiction may imagine.

Carnivorous plants are particularly common in Australia, where all but one of the six carnivorous-plant families are represented. Two of these families, Cephalotaceae and Byblidaceae, are unique to this country.

The trapping mechanisms of carnivorous plants may be passive or active. Passive traps may be of the pitfall or the flypaper type. Active traps may be of the flypaper, springtrap or mousetrap types. By "active traps" is meant those which possess special movements that are necessary to the capture of prey or that contribute to its capture.

Perhaps the most spectacular of the carnivorous plants found in Australia are the Pitcher Plants *Nepenthes* and *Cephalotus*. *Nepenthes*, the only genus in the family Nepenthaceae, has about 65 species, of which only one, *Nepenthes mirabilis*, is found in Australia, in rainforests on Queensland's Cape York Peninsula. *Nepenthes mirabilis*, or Tropical Pitcher Plant, is also known from southern China, throughout Malaysia and New Guinea. It is an undershrub or vine, climbing by means of tendrils terminating its large leaves. At the end of the tendril there is often a pendulous pitcher.

The pitchers are of various shapes and up to seven inches long; they are usually green, often with patches and veins of dark red or pink. Two raised, fringed ribs form a pathway leading to the thickened corrugated rim of the mouth, above which is a small spurred lid. From each corrugation on the pitcher rim an inwardly projecting "claw" is developed, associated with which is a nectar gland. These glands, which are also found on the lower surface of the lid, provide the lure attracting insects to the rim of the pitcher. Just below the rim is a broad, smooth and waxy zone or "glacis", a slippery, unwettable surface providing no foothold for an insect. The lower part of the pitcher is the digestive zone, with numerous disc-like glands each in a shallow pit.

An insect venturing onto the glacis loses its footing and falls into the digestive liquid; the slippery surface of the glacis prevents it from crawling out. Some Malaysian species of *Nepenthes* have enormous pitchers credited with catching small mammals and birds!

Several organisms are able to make their homes within the pitcher. There are spiders which live nowhere else, preying on insects attracted there. Blue-green algae, protozoans, desmids and diatoms, rotifers, oligochaetes, crustaceans and dipteran larvae have been found amongst the "aquatic flora and fauna" of pitchers.

Until it is well developed the pitcher lid remains hermetically sealed by a dense pad of interweaving hairs. Even in unopened pitchers there is abundant secretion. Since the liquid

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Pitcher of *Nepenthes mirabilis.* Note the fringed ribs which form the pathway, the venation on the pitcher wall, and the spurred lid. (Photo: S. Jacobs).

within unopened pitchers remains sterile it has been effectively used for bathing sore eyes and inflamed skin.

Cephalotus follicularis, the Western Australian Pitcher Plant, is restricted to the acid, peaty soils in swamplands of the south-west of Western Australia. It is the only species in the only genus in the family Cephalotaceae. It is a low rosetted plant with a thick branching rootstock bearing numerous clusters of pitchers. It has two kinds of leaves. The conventional leaves are oval, shiny, green and fleshy on tapering stalks. The pitcher leaves are often so brightly coloured that they are sometimes mistaken for flowers. Although the actual flowers, borne on a tall stem, are very small, pale green, and lack petals, they have a characteristic heavy, sweet perfume.

In a shady place the pitchers may be entirely green, but when growing in sunshine they assume brilliant red and purple hues. Up to two inches long, they resemble a decorated slipper at one end and a lidded jug at the other. The lid is latticed with coloured veins, between which are patches of translucent tissue rather like window panes. As with *Nepenthes,* this lid remains closed until the pitcher is fully developed. The pitcher is strengthened by three broad, raised ribs fringed with long bristles. The pitcher mouth is surrounded with twenty-four shiny, dark-red ribs, each curving over into the pitcher throat and ending in a sharply downpointed tooth. Inside, below this formidable array of dark teeth, is a smooth white ledge also sloping downwards and overhanging the cavity of the pitcher. On this ledge, as well as on the lid, are nectar glands. Beneath the ledge is the glacis, the upper part of which is covered with digestive glands. In the lower half of the pitcher there is on each side a kidney-shaped, deeply red-coloured "lateral gland mass", the function of which is also digestive. The bottom of the pitcher has no glands, but contains the fluid in which the insects are digested.

Insects attracted to the pitcher by the nectar at its mouth are guided by the inward and downward projecting ribs on to the glacis, from which they tumble into the digestive fluid below. The unfortunate victims are prevented from escaping by the sloping ledge which, like the mouth of a lobster pot, permits one-way traffic only.

The prey of the genera *Byblis* and *Drosera* is caught in a sticky mass rather like the old-fashioned flypaper rolls that used to be hung from ceilings. *Byblis,* the only genus in the family Byblidaceae, is confined to Australia. There are two species, *Byblis liniflora* and *Byblis gigantea.* The latter is the larger plant, and is found in drying flats and sandy swamps in Western Australia. It is commonly known as the Rainbow Plant because of its pinkish-mauve, iridescent flowers. *Byblis liniflora* is a much finer, smaller plant found near watercourses and swamps in Western Australia, the Northern Territory and Queensland.

Byblis plants are covered with numerous glands of two types, sticky glands and digestive glands. The sticky glands are on the ends of long hairs and exude a gluey substance which catches prey. The digestive glands lie close to the surface of the stems and leaves. A captured insect, while struggling in the grasp of the long hairs, comes in contact with the digestive glands and is slowly consumed.

One small wingless insect, a capsid or Leaf Bug, has made its home on the plant and moves freely over the sticky glands without becoming entangled. It feeds on the plant's captives.

In contrast to the passive flypaper trap of *Byblis* is the active flypaper trap of *Drosera.* The various species of *Drosera,* commonly known as Sundews, present a wide variety of leaf form. In all species the leaves are covered with fine hairy tentacles tipped with sticky red glands. These tentacles are active traps which move to ensnare their prey. An insect's slightest struggle not only brings it into contact with other tentacles, but each tentacle transmits a stimulus to others, and in response they, too, bend towards the centre of the leaf to help enfold the prey. Also, each tentacle secretes a digestive juice from the gland at its tip. After a few days the tentacles straighten out ready to trap the next victim. As well as glandular tentacles, the leaves of Sundews have unstalked glands or papillae. Both tentacle glands and papillae appear to be involved in absorption of prey.

Drosera (in the family Droseraceae) is of world-wide distribution, reaching its greatest diversity in Australia, where it is represented by some 56 species. It is common in damp or swampy places. Some species are found in open forest, scrub, heath or sand-plain habitats. Sundews are notable for their delicate white or brightly-coloured flowers. Many of them are small, rosetted plants; others are erect and trail across bushes for support. Early settlers extracted a red dye from them which they used as ink.

Like *Byblis*, Sundews have an insect immune to the dangers of the tentacles. An Assassin Bug, coloured green with red dots, in simulation of their leaves, lives only on Sundews, feeding on trapped insects.

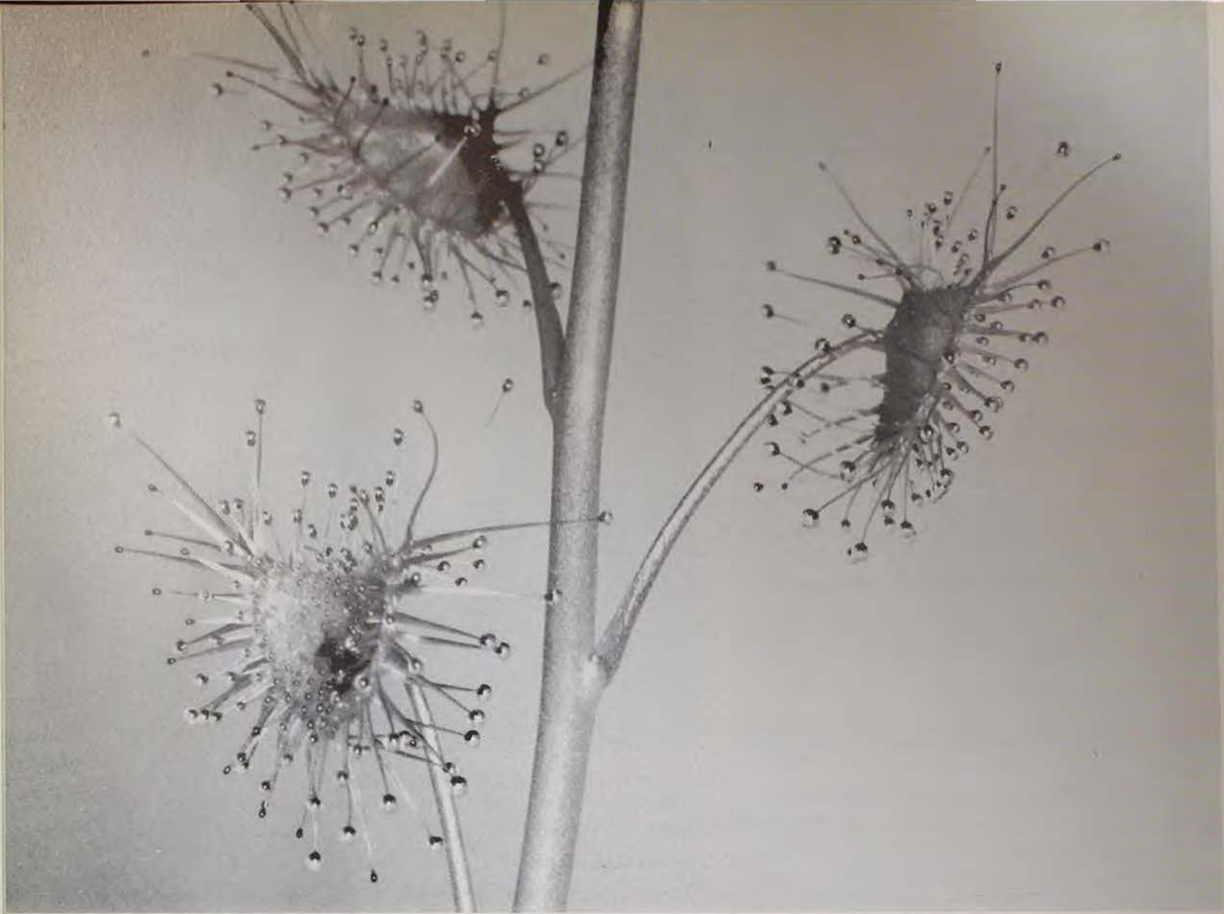
Also in the Droseraceae are *Dionaea*, the well-known Venus' Flytrap, and the no less remarkable *Aldrovanda* or Waterwheel Plant. The former of these does not grow wild in Australia, but is commonly grown in glasshouses; the latter, however, does occur wild in this country.

The Waterwheel Plant *(Aldrovanda vesiculosa)*, a cosmopolitan species, is found in quiet waters of lakes, ditches and swamps near Rockhampton, Queensland, and in the Kimberleys of Western Australia. It looks rather like an underwater bottlebrush floating erect just below the surface. The small flowers emerge above the water with five white petals. This plant is quite rootless, and consists of a slender stem clothed with whorls of leaves. Each whorl has eight leaves mutually attached at their bases like the spokes of a wheel. Along the thickened ends of the leaf-blades are many long, sensitive hairs. Anything brushing against them causes the thin outer edges of the leaf to fold quickly together. Interlocking spines on the leaf-margins prevent the victim's escape. As there are narrow gaps at each end, the quick expulsion of water through them as the leaf closes carries the prey down towards the midrib, where a cavity containing digestive and absorptive glands is situated.

Leaf of *Nepenthes mirabilis*, showing the tendril to be an extension of the mid-rib. Note the elevated pathway on the pitcher wall formed by two raised ribs, the patterning on the glacis, and the corrugations around the pitcher's rim. (Photo: S. Jacobs).

The largest genus of carnivorous plants is *Utricularia*, with about 275 species, of which 40 are found in Australia. It is a member of the family Lentibulariaceae. The flowers of the various species of *Utricularia*, commonly known as Fairy Aprons, are brightly coloured purple, red, yellow or blue, and are two-lipped. The upper lip of the corolla is usually much the

Pitchers of *Cephalotus follicularis*. (Photo: S. Jacobs).



aves of *Drosera auriculata*, showing glandular tentacles. The af on the lower left holds the remains of a partly digested it. (Photo: S. Jacobs).

smaller; the lower lip is larger and apron-shaped. *Utricularia* is a member of the family Lentibulariaceae. The Australian species of *Utricularia*, also known as Bladderworts, are widespread in damp or swampy places. Most are terrestrial but some are floating plants, submerged in water and not rooted. In terrestrial species the leaves are variously divided, and small bladder-like traps are developed on the stolons. Aquatic species have very divided leaves, on the finer segments of which are the bladders.

Perhaps the Bladderworts are the most diabolical of all the carnivorous plants, despite the minute size of their traps. Although these traps exhibit a staggering variety of forms, the principle of operation is the same for all of them. At its free, open end the bladder is closed by a valve-like door which opens inwards. From the outer surface of the door projects a series of long, narrow, sensitive hairs as well as glands which exude sugar and mucilage as a bait. This door is pressed firmly against its threshold and made watertight by a thin membrane. Stalked hairs on the inner wall of the bladder function as suction pumps, withdrawing water from the cavity of the bladder and creating a partial vacuum. The trap is thus "set", and when an animal coming into contact with the hairs projecting from the door's exterior causes it to open inwards a rapid inrush of water carries the unfortunate creature into the bladder. The bladder fills with water, closing the door behind its captive. Once more water is expelled and the trap set for another victim.

The genus *Polypompholyx*, comprising two species, is also in the family Lentibulariaceae, but differs from *Utricularia* in having four pink calyx lobes instead of five. *Polypompholyx* is found only in Australia in damp or swampy areas near the coast and some inland watercourses of Victoria, South Australia and Western Australia. The traps of *Polypompholyx* are similar to those of *Utricularia* species.

There has been a great deal of argument on the nature of the disintegration of the animals trapped by carnivorous plants. Some have attributed this to a digestive process by proteolytic enzymes secreted by the plant with an acid which facilitates their action; others have regarded it as a process of bacterial decay. Although there is strong evidence for the former of these hypotheses, it is probable that both bacterial decay and autolysis by the enzymes of the dead animal contribute to some extent to the disintegration of the prey.

Carnivorous plants usually grow in rather swampy soils with a low inorganic nitrogen content, or in water. Normally, the green plant obtains its nitrogen as soluble nitrates or ammonium compounds which are continuously formed by bacteria in the soil. These important micro-organisms are, however, rare in wet or swampy habitats owing to poor aeration, so nitrate content is low. It has been shown that many carnivorous plants can ingest various animal proteins, which improves their growth compared to that of control plants without such proteins. Further, since oxygen is essential in enabling plants to take up nitrogen and various ions, any reduction of demands made on a limited oxygen supply is advantageous. As far as aquatic plants are concerned, oxygen is a rare and precious commodity. The substrates in which carnivorous plants grow are notoriously poor, and there is evidence to suggest that these plants obtain substances other than nitrogen from their animal prey. In particular, potassium and phosphorus, both essential to protein synthesis, can be acquired in this manner.

What is it about carnivorous plants that leads us to share the feelings of the eighteenth century naturalists who regarded them as *miraculae naturae*? We do so, perhaps, because of their varied and contrived traps which, although composed of structures common enough elsewhere among plants, are specialized organs for the capture and digestion of prey, turning the tables on animals which, directly or indirectly, are herbivores.

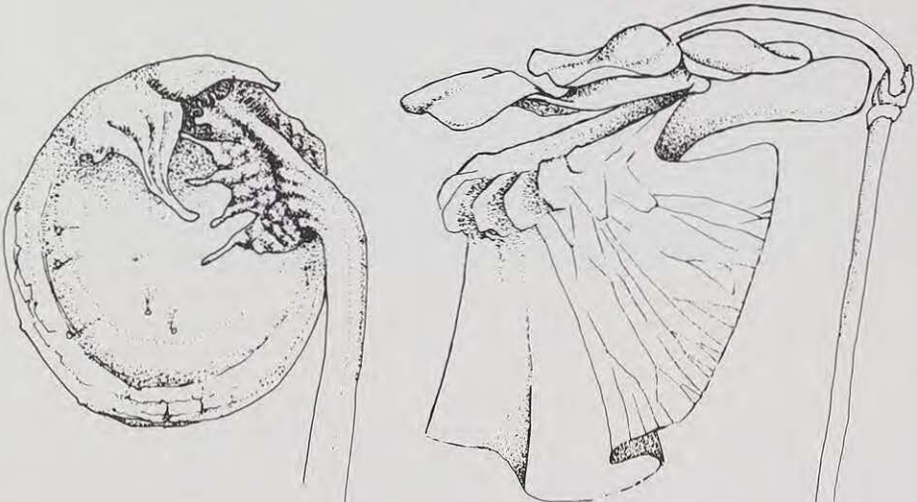
FURTHER READING

Bentley, L., and Threadgall, C. (1967): *Plants that Eat Animals*, Bodley Head, London.

Darwin, C. (1875): *Insectivorous Plants*, John Murray, London.

Erickson, R. (1968): *Plants of Prey in Australia*, Lamb Publications, Osborne Park, Western Australia.

Lloyd, F. E. (1942): *The Carnivorous Plants*, Chronica Botanica Company, Waltham, Mass., U.S.A.



Bladder (left), x 50, and flower (right) x 9, of *Utricularia dichotoma*. (Drawing by H. Bryant).

WITH A THOUSAND SEA LIONS ON THE AUCKLAND ISLANDS

By JUDITH E. KING

and BASIL J. MARLOW

JUST about a year ago we formed exactly half of the human population of a subantarctic island, and shared our drinking water with seal pups who regarded the stream as an ideal swimming pool. We were also in the midst of a large breeding colony of sea lions, and, with no regret, had seen nothing of "civilization" for three months.

This delightful state of affairs came about because we had been lucky enough to be able to join a New Zealand expedition to the Auckland Islands. Organised by the New Zealand Department of Lands and Survey, and considerably subsidized by them and by the National Science Foundation of America, a survey of the Auckland Islands was to be carried out and the present status of plants, insects, birds and mammals, both native and introduced, was to be investigated. The islands have been a flora and fauna reserve since 1934 and are normally uninhabited. Recent scientific visits have been in 1954, 1962-63 and 1966, while wartime coast-watching parties were there between 1941 and 1945.

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The Auckland Islands, about 200 miles south of New Zealand, consist of two large main islands (Auckland, Adams), four smaller islands (Disappointment, Rose, Enderby, Ewing) and numerous small islets. The group was discovered in 1806; Maoris from the Chatham Islands settled there from 1842 to 1856, the Southern Whale Fishery Company leased the islands from the Crown, and the chief commissioner to the company, Charles Enderby, and his English colonists established a settlement in 1849 that lasted till 1852. Pastoral leases were granted for a while, and sheep were run there, but the chief visitors to these islands in the early days were in the main the sealers, who had turned their attention to the Aucklands when seals ran low in other places, and the unwilling victims of shipwrecks.

Between 1880 and 1927 there were regular visits to the islands by New Zealand Government vessels which established storage depots with food and clothing, boatsheds with boats, and numerous signposts indicating the way to the nearest food depot. They also took and liberated sheep, goats and cattle as food supplies; pigs and rabbits had been introduced earlier by the settlers. These precautions were needed, and doubtless appreciated, as there were several spectacular shipwrecks on the islands — not to be wondered at when one sees the sheer cliffs, rock-studded reefs, fierce winds and enormous waves. However, our first sight of these islands was under different conditions and we landed in a rare calm under a cloudless sky.

Two trips from Dunedin, each of a queasy 40 hours, were needed to transport the stores and the 18 people for the first six weeks. At the end of that time about half these expedition members returned to New Zealand to be replaced by new participants, while a few lucky people, ourselves among them, were able to stay the full period. A base camp was set up at Ranui Cove on the main Auckland Island, in the wooden buildings used by the coastwatchers, and from this base people went forth for varying periods to subsidiary tent camps while they pursued their particular research.

A mass of sleeping female Hooker's Sea Lions at Sandy Bay, Enderby Island.

Our aim was to study the sea lions during their breeding season, and as their main breeding colony is on the 3-miles-long Enderby Island, at the north-eastern end of the main island, we set up our permanent camp there. We slept in tents, and at first our daytime shelter, store and kitchen was a corrugated iron boatshed first put up for castaways many decades earlier. But this leaked like the proverbial sieve, and we soon erected as living quarters an 8-feet-square plywood "disaster hut", which we received through the good offices of Hugh Best, from the University of Canterbury, New Zealand, a fellow seal watcher. To be sheltered as much as possible from the perpetual winds of the island our camp was hidden in a rata forest in a strange Walt Disney world of moss-covered mounds supporting wind-twisted branches surmounted by a canopy of leaves and, in season, a blush of fluffy red flowers. Bell birds resounded through the forest as they searched for food, yellow-eyed penguins slept prone on the mounds, and mice scuttled away to hide under the roots.

Sea lions at the east end of Sandy Bay. Note the kelp cast up on the beach by a storm the previous night.

A large bull sea lion at Sandy Bay.

Hooker's Sea Lion *(Phocarctos hookeri)*, confined to the New Zealand region, has its headquarters on the Auckland Islands, and has probably its largest breeding colony in Sandy Bay on Enderby Island. A smaller colony is known from Campbell Island, a few animals have been born on the Snares, stragglers are known from Stewart Island and Macquarie Island, and sometimes some reach South Island, New Zealand. This sea lion, although known earlier to the rapacious sealers, and seen by a French expedition on its way to explore the Antarctic, was first named and made known to zoology in 1844 in *The Zoology of the Voyage of the "Erebus" and "Terror"*. These two ships were taking part in the British expedition to the Antarctic of 1839-43, and the sea lion was named after Sir Joseph Hooker, the botanist with this expedition. Although some introduced mammals were available as food for some of the castaways, the sea lions must also have formed a welcome source of food. Captain Thomas Musgrave, marooned for 20 months between January 1864 and September 1865, certainly ate them and wrote his journals in their blood.

This sea lion is quickly identified by its small, but visible, external ear pinnae, and by the way it can bring its hind flippers forwards under its body, as a member of the family Otariidae in the order Pinnipedia. The lack of a thick undercoat of fine fur and the rather blunt nose indicate that it is not a fur seal, but a sea lion. Other sea lions of different genera may be found in the Californian area *(Zalophus)*, along the coasts of the northern Pacific *(Eumetopias)*, and along the southern coasts of South America *(Otaria)*. The only other sea lion is the Australian Sea Lion *(Neophoca cinerea)*, which lives on many of the islands from Houtman Abrolhos in Western Australia to Kangaroo Island in South Australia. We have already been studying the latter animal, and this expedition was a fine opportunity to make similar observations on Hooker's Sea Lion. Then we would be able to compare the habits, behaviour and anatomy of these two relatively close neighbours. There have been suggestions that the two sea lions are congeneric, possibly even conspecific, and we hope eventually to have enough information to try and solve this puzzle.

We wanted, primarily, to study the behaviour of Hooker's Sea Lion during its breeding season, and we were very lucky in that the timing of the expedition itself fitted this aim perfectly. As we landed for the first time on Enderby Island on 1st December 1972 the long, curved beach, some 500 yards long and aptly named Sandy Bay was sparsely populated by about 60 male sea lions, posted at intervals along the sand. By the time we left, at the end of February 1973, the beach was sometimes deserted and sometimes had up to 20 animals scattered along it. But in the middle of this period, about six weeks after we landed, it was quite different. Female seals had been coming ashore almost from the time we ourselves landed; they joined together in groups, one seeming to attract another. A plump, wet seal would emerge from the sea, survey the scene, and then hurriedly gallop towards a group of cows as if she were late for an appointment. The first pup was born on 7th December. By 11th January there were 400 pups and, at the time of this particular count, somewhere in the region of 270 cows and 90 bulls. It was not easy to count the population on the beach, in spite of the fact that we were so close to it; the cows in particular would lie in heaps of 50 or more and it was nearly impossible to tell where one animal ended

and the next one began. The pups, too, would gather in highly packed groups or pods, or else lie singly, hidden behind their mothers, but as we all did frequent counts a reasonably good idea of the increasing numbers was obtained.

Activity on the beach was almost constant — a restless female, twisting and turning, would produce a grey amniotic sac from her hind end, and this would soon burst to reveal a small black head or a pair of limp, grey hind flippers. More twisting covered the little face with sand, but soon the whole pup was beside its mother, shaking itself, bleating, and moving on its wobbly flippers. The expulsion of the placenta caused a flurry of skuas and silver gulls, who quickly devoured their meal. These birds were useful on the very crowded beach as sure indicators of the presence of a placenta, so that our attention was drawn to a birth we might otherwise have missed. Older pups would be in groups, playing or fighting with their fellows, wandering about the beach picking up stones or shaking seaweed, or hungrily bleating for their mothers. Cows returning from a trip to sea call to their pups and avoid the interested attentions of the bulls. The big bulls themselves sit on their chosen bit of sand and defend if from other bulls and "huff" loudly at their neighbours. And yet there were times when peace descended and the whole beach seemed to be asleep and many of the inhabitants were even snoring. A well-fed, sleeping pup is the picture of contentment — lying on his back, flippers relaxed and spread wide, chocolate-brown fur dry and fluffy, and a bulging stomach indicating a recent satisfying meal.

Along the landward side of Sandy Bay, and about 10 feet higher than the beach itself, was an area we called the "golf course" — a sward of rabbit-mown grass in the drier parts and a moving carpet of liverworts in the wetter regions. In the grass-covered sandhills many rabbits made their burrows — probably a significant factor in the mortality of the pups. Sheltering from the sun, rain or wind a pup would put the front half of its body into a burrow. A few other pups jostling each other would gradually inch the first pup further into the burrow until, with body encased in the burrow and flippers pressed to its sides, it would find it had no room to turn round and no means of propelling itself backwards. Such unlucky pups could only possibly move forward a little — getting more deeply into trouble. We dug several pups out of such unhappy situations, but we found others too late, after they had starved to death; the numbers of bones of young pups scattered near rabbit holes testify that this is no uncommon cause of death.

As the pups got older they became more adventurous and would leave the beach and move inland, so that little groups of them could be found asleep in the rata forest. A cow returning from the sea goes to the area where she last left her pup and calls for it. We followed a cow for 300 yards or so as she moved along obviously well-worn paths through the forest, calling and calling. At last she got a reply she recognised and turned towards it, and the two calls gradually got closer to each other. Eventually the pup reached his mother, was sniffed and accepted, and, wriggling estatically, got on with his meal. Except when feeding, most pups other than the very young are separate from their mothers. Although some may be on the beach, many more are in the forest, particularly near a muddy stream where slippery

Sleeping sea lion cows and pups at Sandy Bay. The pup in the foreground is suckling.

Two Sandy Bay pups occupied with a piece of kelp.

A small pod of *Phocarctos* pups, and other single pups with their mothers — one of them suckling. Sandy Bay.

dips down the bank have been created as the pups climb in and out, stir up the water and practise swimming.

For an aquatic mammal, *Phocarctos* gets around the island very well, and it was not unusual, while we were making our way through almost impenetrable undergrowth, to disturb a sleeping young bull or a mother feeding her pup. A new-born pup was discovered in a hollow in the middle of the island, and wandering animals were often seen round the coast in areas where, because of high cliffs, they would have had a long walk back to the sea.

Because of the raised "golf course" along the back of the beach, watching the seals was comparatively easy, and by walking along this and using binoculars most parts of the beach could be kept under observation. But this does not take into account the frequent heavy rain, nor the constant piercing winds — so we built a shelter, half sunk in the sand, with walls of driftwood planks and a roof of tin. This was protection from some of the weather, but the visibility was limited — and the pups took a liking to it, too, and had to be evicted regularly. It was no protection, either, against the class of unattached, unemployed young males that we called Sams (sub-adult males), who would go around looking for something to do, like a teenage gang. They were not really aggressive, these Sams — perhaps 6 feet long but appearing larger because of their bulk — but their teeth were big and none too clean and it was considered that discretion was a good thing. So, with the contorted branches of *Myrsine* a tower 10 feet high was built on which three or four people could sit relatively comfortably and survey the beach. We were exposed to the weather, but at least didn't need to keep watching behind for marauding seals.

Another part of our work was collecting specimens — bones, dead animals, anything that was possible. Bones presented little problem except for the purely physical one of taking a heavy rucksack full of them back to camp. Isolated bones, in a fair state of completeness, were found tossed along the high-water mark of some of the stony beaches. Although just about everything was collected, when a final count was made it was amazing how few there were of some bones (7 tibiae) and how many of others (53 humeri). On our travels round the island we were fortunate in finding the occasional "leather lady" — a dead seal whose dried skin concealed a fairly complete skeleton — and other relatively undisturbed skeletons of animals which had died at the edge of the forest. Dead pups were easy to locate, but less easy to acquire: if they were on "the other side" of the main mass of seals they were lost to us, and even with an accessible body one had to be very quick to beat the skuas if one wanted soft tissues to preserve. We killed no animals for our collections, relying entirely on natural mortality, and, apart from pups, only three dead females were found. The skeletons found about the island were nearly all female, too — where do the males die?

In earlier days, before the sealers had their way, there were large numbers of New Zealand Fur Seals *(Arctocephalus forsteri)* on the Auckland Islands, as well as sea lions. These were soon cleared off, and fur seals have not been seen in any numbers since. But fur seals are showing a general increase in numbers everywhere now, and are beginning to be seen again on the Aucklands. On Enderby, two, three or four fur seals were seen at intervals on the more rocky parts of the coast, and on one occasion nine animals were seen together. They never waited long, but their long and very pointed noses distinguished them satisfactorily from the sea lions. There were other pinniped visitors, too. Before we had been on the island a week we were surprised to see a very long, slim seal at the far end of the beach — a 9 foot Leopard Seal *(Hydrurga leptonyx)*. It was a young male who, in the course of his youthful wanderings, spent a single day on our island. He opened his mouth wide at us, displaying his teeth, and tried to keep us under observation while we were photographing him. Elephant Seals *(Mirounga leonina)* were a little more plentiful, and during our stay 10 were seen. Two were females, probably adult, one accompanied by a yearling, and the rest were young, except for a tantalizing two-minute glimpse that we had of an adult bull as he reared his vast bulk out of the sea, looked around for a moment and then vanished.

In our three months on Enderby we saw the whole of the breeding season of Hooker's Sea Lion, and we saw fur seals, Elephant Seals and a Leopard Seal — four genera of pinnipeds all previously unknown to us in the wild. The notes that were made, the bones, lice and preserved parts that were collected, and the photographs that were taken — these are just the tangible records of a most profitable and enjoyable expedition. There is much work yet to be done on all these collections, but even now our knowledge of sea lions in general and *Phocarctos* in particular has increased enormously. Our grateful thanks are due to the Trustees of the Australian Museum, the Ian Potter Foundation, the New Zealand Department of Lands and Survey, and the Wildlife Service of the New Zealand Department of Internal Affairs, who made our participation possible.

FURTHER READING

Taylor, R. H., 1971. "Influence of Man on Vegetation and Wildlife of Enderby and Rose Islands, Auckland Islands." *New Zealand Journal of Botany*", Vol. 9, No. 2, pages 225-268.

Yaldwyn, J. C., 1964. "The Auckland Islands Expedition 1962-63." *Australian Natural History*, Vol. 14, No. 9, pages 273-279.

Northeast Bay, Enderby Island. The stony beach on the right, and the grassy area inland from it, were a profitable source of bones.

HOW MANY AUSTRALIANS?
SOME DEMOGRAPHIC VIEWPOINTS

By W. D. BORRIE

DEMOGRAPHIC trends in Australia over the past quarter-century or so look disarmingly constant — a birth-rate around 20 to 22 per thousand of population, a death-rate around 9 or 10 per 1,000, and consequently a natural growth rate between about 1 and 1.2 per cent, and a substantial inflow of immigrants from overseas. This inflow of immigrants has fluctuated over a fairly wide range, but always yielding a very substantial net gain, to the extent that over the whole period since World War II the net gain of new settlers and their own natural increase have accounted for about 55 per cent of the total population growth.

Consequently, population has grown steadily in Australia from about 7.6 million in 1947 to just on 13 million today, and it may seem very easy to deduce from all this that the population is likely to go on increasing in the future at a similar rate. It *may* do so, but prediction about the future looks extremely hazardous when it is realised that the consistency of population growth rate in the past, with the annual rate of growth from all factors averaging about 2 per cent a year, or sufficient to double the population every 35 years, has not in fact been the product of a set of consistent factors, but has been the production of a series of very considerable variations born of structural and sociological changes that have coalesced, almost by a series of fortuitous circumstances, into a time series yielding almost constant growth rates.

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Much is heard today about the *global* need for "zero population growth", a concept with which no sensible person can disagree. Accepting this as the ideal for some time in the future is one thing, but achieving it at a given point of time by deliberate policy measures is quite another. Likewise, anticipating how Australians will react in the future with regard to such factors as age at marriage, proportions who will marry, and size of family, is also extremely difficult to predict. This proposition is supported by a cursory examination of what has happened over these matters during the past 25 years or so.

In the 1930's Australians, like the peoples of many other "developed" countries, achieved the lowest birth-rates ever recorded, around 17 per 1,000 of population. In addition, the flow of immigrants, which had been at flood-tide during the 'twenties, had dried up. The net result was that, using the net reproduction rate as the index of measurement — which was precisely what our "zero population" advocates hold up as the desideratum today — the pundits of the time projected that the Australian population was bound to go into decline and would never reach a maximum of 9 million! Certainly that generation knew how to react rationally to wretched economic conditions without the advantage of the progesterone pill (which was not marketed until 1961), and it was anticipated that the trends towards the small family which they had established would be perpetuated in the future. Furthermore, births had fallen so sharply that it seemed that the supply of parents to rear the next generation would go on decreasing almost indefinitely.

Yet post-war trends belied the whole range of these projections. The population did *not* decline and natural increase alone pushed growth rates along year by year by 1 per cent and more. Why did the projections of the 'thirties go so far wrong?

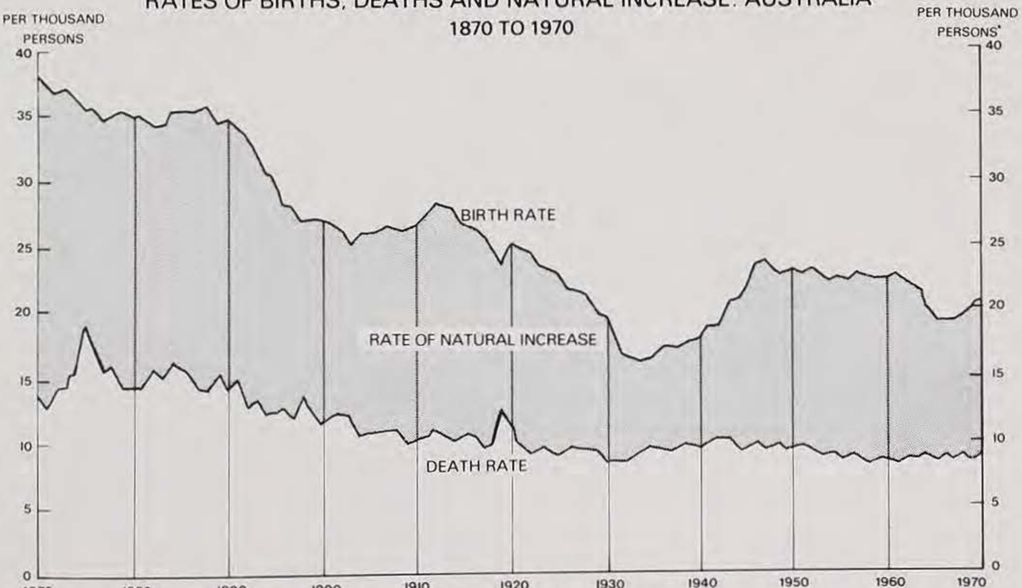
First, marriages postponed during the depression years of the 'thirties and during the war years occurred in much above normal proportions in the early post-war years. Second, a major sociological revolution began after the war with regard to the ages of marriage of both men and women and in the proportions who married. For example, whereas in pre-war years about a third of women were married by age 22.5 years, by 1961 almost 60 per cent were married by that age. A similar trend occurred amongst men. Today almost 95 per cent of women will have married by age 50, compared with only about 86 per cent in pre-war years.

These factors, rather than major changes in family size, were responsible for the post-war "baby boom" whereas it seems to be commonly assumed that the "baby boom" was caused by families suddenly becoming much larger. Furthermore, the changes in marriage patterns were so great that they completely overcame the declines in the numbers of births expected from the "deficit cohorts" resulting from the low birth-rates of the 'thirties. And once such a "baby boom" occurs, its effects will be felt for several generations into the future. Consequently, now, when the post-war "baby boom" generation are beginning to marry and rear *their* children, the numbers of births are rising again as a sort of second-generation echo-effect of the boom 25 years ago.

Consequently, it now seems reasonable to project that population will continue to grow for a considerable time into the future because of this new change in age structure which is marked by the very large numbers of young people who will be entering the marriageable and child-bearing age groups. This assumption seems reasonable, judged by all available evidence. In particular, there is no evidence to suggest that the "marriage revolution" of the past quarter-century will be reversed. The pattern of young marriages and almost universal marriage appears to be firmly established. Nor is there evidence that young people are avoiding the responsibility of parenthood after marriage. Infertility has decreased, and in addition there has been a marked increase in pre-marital births compared with the 'thirties. Popular family-size appears to be the two and three child family. There is no sign of a revival of the large family of four and more children. Early marriage, some six years of child-bearing with the whole business of procreation out of the way by a woman's age of 30 years, is the modern pattern. But with expectations of life from birth now over 70 years, this average family pattern is sufficient to establish growth rates (given present marriage patterns as a constant) of around 1 per cent a year.

If a population is subject over about half a century to constant fertility and mortality schedules (which, of course, is seldom the case) it will assume a fixed age and sex structure and

RATES OF BIRTHS, DEATHS AND NATURAL INCREASE: AUSTRALIA
1870 TO 1970



NOTE: EXCLUDES PARTICULARS OF FULL-BLOOD ABORIGINES BEFORE 1967 a constant rate of growth. This is known as a *stable* population. Given Australian fertility and mortality schedules, it requires only about 2.1 children per woman to ensure generation replacement, but the women who bear children must also carry the replacements for those who do not bear children — for example most spinsters, and married but infertile couples.

Allowing for these factors, the reproductive patterns of a stable population derived from Australian vital data which would be required to produce a situation of zero population growth would be, in terms of *completed family size*:

Children to each *woman*:	2.11
Children to each *married woman*:	2.35
Children to each *fertile married woman*:	2.54

In other words, "zero growth" requires not two children per family, but 2.35 children per family when married women are taken as the base, or 2.54 children when fertile married women are taken as the base.

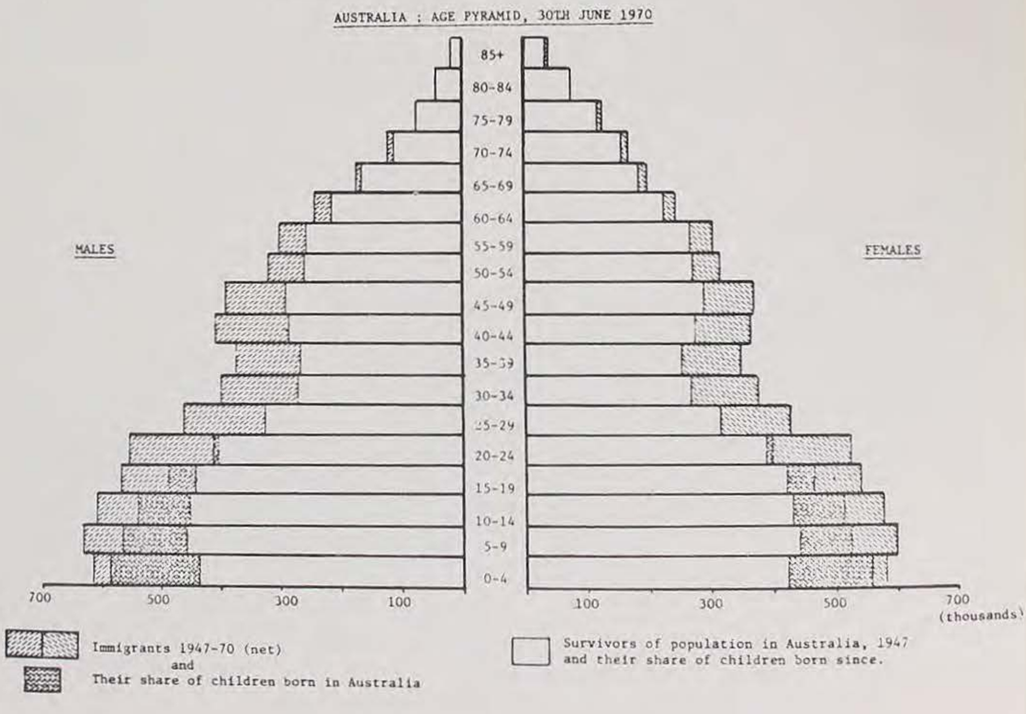
Now these figures may be compared with the actual situation as revealed in census data. The average issue of existing marriages (whether fertile or not) at the time of the censuses in the case of women who had completed their child-bearing (i.e., at ages 45-49) was as follows:

Date of Census	Average Issue
1911	5.02
1921	4.02
1947	2.77
1954	2.43
1961	2.50
1966	2.66

These figures reveal both that the small family is not a thing of recent origin and that completed family size in Australia is really not so very far above replacement level — the reduction, on average, of about one child for every three married women would produce a zero growth situation.

Yet the population is growing from the balance of births over deaths by about 1.2 per cent a year. Why is this? Primarily it is because the present age distribution has a higher proportion of population in the essential child-bearing years (roughly 20-35) than would be the case in a stable population based on current vital data. In others words, we are still generating growth from the post-war "baby boom". Consequently, the *immediate* achievement of zero growth, even if immigration was abolished tomorrow, is not a likely possibility for Australia. What the long term may hold is quite another matter.

AUSTRALIA: IMPACT OF IMMIGRATION, 1947-1970



Turning to the factor of *international immigration*, this, as already emphasized, has accounted for just over half the nation's growth since 1945. The flow has fluctuated. It reached a record peak in the fiscal year 1969-70 with 185,000 "permanent" arrivals. These included 132,000 "settler" arrivals — a rise of about 45,000 compared with the early 'sixties. This peak flow was bound to decline, but the steepness of the decline was accentuated by a worsening employment in Australia and mounting criticism of migration as one of the "sacred cows" of the post-war years. In 1972 the McMahon Government reduced the "target" figure of permanent arrivals from 180,000 to 130,000, and the Labour Government has spoken of 110,000 as their new objective (the further reduction being achieved by limiting categories of assisted immigration), but there is no suggestion so far of eliminating immigration altogether, and in any case Australia has been attracting each year about 50,000 new settlers who have come here unaided.

Thus a continuing, though reduced, flow of immigrants seems to be the most likely future pattern, and if the Government sustains its new target of 110,000 settlers the *net* gain of arrivals over departures is likely to remain in the region of 65,000 to 70,000 a year. This will supplement the growth impetus from natural increase inherent within the present age-structure of the population. (However, the net gain of arrivals over departures may fall somewhat lower over the next year or two because of the very large *outflow* following from the very high inflow of immigrants in 1969, 1970 and 1971.)

Consider now the growth likely to follow from natural increase alone under the assumptions of

(a) constant age specific fertility rates at the estimated average level of 1970-75;

(b) fertility declining to a net reproduction rate of replacement or unity by 1980-85 and thereafter remaining constant at that level;

(c) no further immigration after 1970.

The results of such projections are summaried in the following table. The figures refer to the expected population at the mid-point of each five-year period.

Projections of Population (in Millions) Under Different Assumptions, Together with Resulting Birth and Natural Increase Rates per 1,000 of Population

		1970-75	2000-05	2030-35
(1)	Assuming constant fertility at average 1970-75 levels			
	Population at beginning of period	12.2	17.5	24.6
	Crude birth-rate	20.4	20.8	20.8
	Natural increase	10.5	11.1	10.9
(2)	Assuming declining fertility to NRR 1 by 1980-85, and thereafter constant			
	Population at beginning of period	12.2	15.3	16.7
	Crude birth-rate	18.6	15.2	14.1
	Natural increase	8.8	4.2	0.2

A projection running into the twenty-first century must be in great measure only a guess, but it does serve to indicate the growth potential in current age structure. Whether fertility *will* decline to zero growth level by 1985 is also a very difficult thing to gauge at the moment, but, in many other countries with economic and social structures like our own, fertility has been dropping rapidly since 1960. In U.S.A. the birth-rate is now around 15 per 1,000 (the lowest level ever recorded) and fertility is in fact barely at replacement level in terms of the net reproduction rate. The same is true of several European countries. Australia has never remained the odd man out in these comparative trends, but so far fertility is holding up here. But even if it does decline, as in U.S.A., the growth potential in the Australian population is substantial, as the above figures have shown.

Now examine projections in a little more detail for a shorter period, say to the year 2000, using for this purpose the last available projections prepared by the Commonwealth Bureau of Census and Statistics, which assume constant fertility and mortality and provide five different assumptions relating to immigration. The figures are presented below.

In terms of the current Government's policy with regard to immigration the higher migration assumptions of these projections now seem unrealistic. Possibly the range 60,000 to 80,000 net immigrant gain a year would seem the most appropriate, yielding a population by A.D. 2000 of 20 or 21 million, given the other assumption of constant fertility. Note that 60,000 new settlers a year yield a total immigrant population

PROJECTED POPULATION OF AUSTRALIA (in thousands)

	1970	1975	1980	1985	1990	1995	2000
(1) 60,000 net migration	12,485.6	13,583.1	14,801.7	16,107.1	17,458.3	18,855.1	20,247.3
(2) 80,000 net migration	12,485.6	13,689.9	15,028.6	16,466.7	17,962.9	19,517.7	21,181.3
(3) 100,000 net migration	12,485.6	13,796.7	15,255.6	16,826.2	18,467.4	20,180.3	22,015.3
(4) 120,000 net migration	12,485.6	13,903.6	15,482.5	17,185.8	18,972.0	20,842.9	22,849.4
(5) 140,000 net migration	12,485.6	14,010.3	15,709.5	17,545.3	19,476.6	21,505.5	23,683.4
(6) no net migration	12,485.6	13,262.6	14,120.8	15,028.5	15,944.6	16,867.3	17,845.1

Assumptions

Fertility: Female age-specific birth-rates and masculinity of births recorded in each State and territory in 1970, i.e., total fertility of 2.86 and G.R.R. of 1.39.

Mortality: Average age-specific mortality rates recorded in each State, territory and Australia for the three years 1965-67 related to the 1966 population.

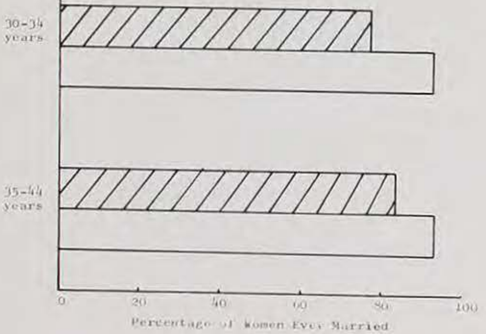
Migration: Five assumptions (as above), plus no migration, with age-sex composition of all future interstate or overseas migration assumed to be the average age-sex distribution of net overseas migration for Australia as a whole for the five years ended June 1970.

gain, 1970-2000, of 2.4 million, and an 80,000 level yields a corresponding figure of 3.4 million. So, if in fact fertility does decline to replacement level by 1985 and remains there, as in our earlier "model", the population could still reach about 17 or 18 million by the end of the century if the current level of immigration is sustained.

Thus growth for some years ahead appears a certainty for Australia, largely because of the country's age structure; but if Australia does follow the lead of U.S.A. and many western European countries, some decline in fertility may be on its way for this country as well; but the signs of such a decline are not yet clearly visible. As for immigration, lower rather than higher levels seem the likely pattern. Using present data for purposes of projecting, a population of 20 million by the end of the century seems a reasonable possibility; but it could be less than this, especially if further controls are exercised over immigration. Perhaps the figure of 20 million by the end of the century may be near the maximum, and the figure of 18 million near the minimum that might be expected, in so far as recent trends and patterns of fertility and immigration can be taken as any guides at all. But the situation at the moment calls for extreme caution with regard to projections: remember how very wrong the projectors of the pre-war years were to be proved by post war events!

Finally, of even greater significance than the precise level of population that may be reached by the end of the century will be its distribution. Are our two major cities already too big? If so, can their populations be redistributed? Where and how can this be done? Or if their population cannot be reduced, at what levels can controls become effective? These are some of the crucial questions for the 30 years ahead, and while Canberra and Albury-Wodonga provide illustrations of what can be done, much more drastic surgery will be necessary if metropolitan growth is to be contained. Wherever the people are to be placed, one thing appears absolutely certain: 85 per cent of Australian people will live in an urban environment, for better or worse.

THE MARRIAGE REVOLUTION



AUSTRALIA'S RAINFOREST PIGEONS

By F. H. J. CROME

Of Australia's 23 species of pigeons, nine are more or less restricted to rainforest vegetation, where they are among the most noticeable types of birds. It is hardly possible to spend a few hours in the lowland rainforests of northern Queensland without seeing or hearing three, four or even seven or eight species. While pigeons inhabiting the drier parts of the continent are, for the most part, plumaged rather drably in shades of brown and grey, rainforest pigeons are generally brightly coloured in greens, purples, and reds, or in starkly contrasting black and white.

The Wompoo Pigeon *(Ptilinopus magnificus)* is a large green bird with a grey head, purple breast and yellow abdomen, and its loud bubbling "wompoo" call is one of the most familiar sounds in our tropical rainforest during the dry season. The Wompoo is also found in New Guinea, where it is smaller and duller in colour than in Australia.

The Purple-crowned Pigeon *(Pt. superbus)* is about one third the size of the Wompoo,

A Wompoo Pigeon in a canopy of Silver Quondong, *Elaeocarpus grandis*. (Photo: E. Slater).

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weighing only around 9 ounces. The male has a green back with brick-red shoulders, and the breast is grey and separated from the white and green abdomen by a broad, navy blue band. The crown is, of course, purple. The female differs in being plain green with a whitish abdomen and a blue spot on the nape.

The Red-crowned Pigeon *(Pt. regina)* is about the size of the Purple-crowned Pigeon, but differs in that it lacks the red shoulders and navy blue chest band, the abdomen is a mixture of pink, yellow and apricot, and the crown is red.

The Black-banded Pigeon *(Pt. cinctus alligator)* is a black-backed bird with a white head and breast and a black band across the chest. The rest of the underparts are grey.

The genus *Ducula*, the Imperial Pigeons, are big birds weighing up to a little over a pound. The single species in Australia, the Torres Strait Pigeon *(D. spillorrhoa)*, is creamy white with black tail and flight feathers and spots on the abdomen.

Of the seven species of brown pigeons or cuckoo doves *(Macropygia)*, only the Brown Pigeon *(M. amboinensis)*, a bright-brown, long-tailed bird, occurs in Australia.

One species of the world-wide genus *Columba*, the White-headed pigeon *(C. norfolciensis)*, occurs naturally in Australia. It is another large pigeon, weighing up to about 18 ounces. The back is iridescent greenish-black, the head white, and the underparts vary from white to dark grey. The White-headed Pigeon is closely related to the White-throated Pigeon *(C. vitiensis)*, which occurs widely in the Pacific.

The Green-winged Pigeon *(Chalcophaps indica)* is a smallish brown pigeon with iridescent green wings.

Finally, we have the Topknot Pigeon *(Lopholaimus antarctica)*, the sole member of its genus. Our largest pigeon, it is blue-grey and has a peculiar chestnut crest. Its relationships remain obscure.

Mention must be made here of the Wonga Pigeon *(Leucosarcia melanoleuca)*, another Australian endemic. It is found in the southern rainforests from Victoria to central Queensland, but it is by no means restricted to this type of vegetation. It is commonly met with in the wetter eucalypt forests also, and so will not be included in the following discussion.

Like most other pigeons, the rainforest species build an extremely fragile-looking nest of twigs and vine tendrils and lay one white egg. The breeding season in northern Queensland for the rainforest pigeons is the dry and the early wet season — July to January and occasionally into February. The only species for which we have detailed field data on breeding are the Purple-crowned Pigeon and the Torres Strait Pigeon. The former's nests are difficult to find in rainforest, as are most pigeon's nests, and those that have been found have been placed nine to twelve feet up in Lawyer Cane *(Calamus)* tangles or in dense leafy areas where several small tree branches cross. It also nests commonly in eucalypt forest bordering rainforest, where it places its nest low down, from about 10 inches to six feet above the ground, in small bushes and trees. In this situation, it is easier to study. The incubation period is about 14 days and both adults take turns at incubating, the male during the day and the female at night. The fledgling period is extremely short, only about seven days. The chick leaves the nest partially feathered and only just capable of flight. The breeding success rate is low — about 25 per cent.

The Torres Strait Pigeon breeds on the offshore islands of north Queensland, and does so in large numbers. I have studied a colony of about 20,000 birds on Low Isles, north of Cairns. In contrast to the Purple-crowned, the incubation period in the Torres Strait Pigeon is 28 days and the fledgling period is likewise longer. The success rate is also high. The long fledgling period of the Torres Strait Pigeon, in contrast to the extreme brevity of that of the Purple-crowned Pigeon, may be due to the lack of predators on these offshore islands.

Far Left
Tropical rainfore with a grove Bangalow Palms (*chontophoenix alex drae)* in the centre the picture. (Photo: Slater).

Cleared rainforest southern Queensla (Photo: E. Slater).

The diet of the rainforest pigeons consists entirely of fruits and seeds, and the species can be divided into two ecological groups according to their digestive systems. The Wompoo, Purple-crowned, Red-crowned, Black-banded, Torres Strait and Topknot Pigeons have relatively thin-walled gizzards and do not take grit. They feed entirely on succulent fruits, their gizzards being devised to strip the pericarp from the fruit, leaving the unscathed seed, which is excreted. Since the sole source of nutrition for these birds is the flesh of the fruit, this flesh must be of high nutritive value.

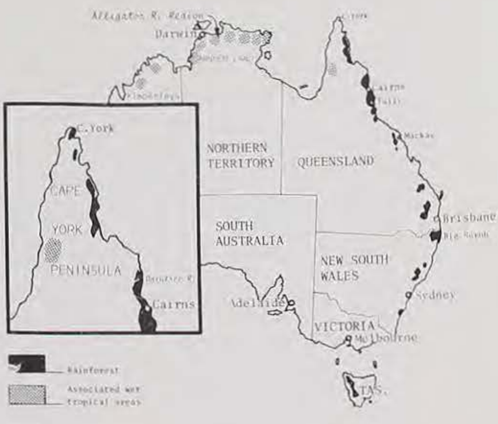
The Brown, White-headed, and Green-winged Pigeons, on the other hand, have thick-walled gizzards and take grit, and are thus able to digest the seed as well as the flesh of the fruit they eat. They can also digest dry fruits and seeds. Because of the extra food-source seeds represent, these birds can survive on fruits with poor-quality flesh.

These two groups have totally different ecological effects on the forest. The latter group, because they digest the seed, are basically predators, whereas the former group act as disseminators of the seeds of their food plants, and so assist the survival of their own food supply.

With the exception of the Green-winged Pigeon, which restricts its feeding entirely to fallen fruits and seeds, all rainforest pigeons feed in the canopy of the forest or in the vegetation from about a yard above the ground to tree-top level. The White-headed Pigeon, however, is reputed to feed occasionally on fallen fruits. The fruits are plucked from the branches with a sideways twist of the head and are swallowed whole. The distensible gape allows relatively enormous fruits to be taken on occasion. I have seen Wompoos swallow fruits up to over an inch in diameter.

The strictly frugivorous nature of our rainforest pigeons means that a year-round supply of fruit is needed for the maintenance of populations, and this raises some interesting ecological questions. Firstly, how does the fruiting regime of the forest affect pigeon populations, and secondly, how do so many apparently competing species apportion the environment to enable them to co-exist? An intensive field investigation in the lowland tropical rainforest of the Mission Beach area has provided some answers.

It was found that each species of fruit plant has a distinct fruiting season, usually lasting only a couple of months, but, because of the staggering of the fruiting times of different species and the large number of species involved, there were trees bearing fruit in every month of the year. The diet of each pigeon species, therefore, changed from month to month throughout the year according to the fruits available and the birds' preferences for particular species. Over a three-year period, more than 80 species of plants were recorded as providing food for the eight species of pigeons in the area. One of the most important observations to come from the study was that, although there was fruit all the year round, it was not abundant at all times and its abundance differed from year to year. The late dry season was the time of maximum fruit abundance and pigeons were most numerous and bred most actively at this time. Co-existence of the pigeons is facilitated by each species taking different fruit and by extensive nomadism from one patch of rainforest to another. While the Wompoo, Brown and Purple-crowned Pigeons occur at Mission Beach throughout the year, the White-headed and Topknot Pigeons occur sporadically, the Torres Strait Pigeon is only



Wompoo and Topknot Pigeons occur in eastern Australia from Cape York to northern New South Wales. The Purple-crowned Pigeon occurs from the Celebes through the Moluccas to New Guinea and into Australia, where it ranges from Cape York to northern New South Wales — and some birds have been picked up as far south as Victoria and Tasmania. The Red-crowned Pigeon has two subspecies in Australia — *Ptilinopus regina regina* in eastern Australia from Cape York to northern New South Wales, and *Pt. r. ewingi* in the Arnhem Land region of the Northern Territory, extending westwards into the Kimberleys. Outside Australia, the Red-crowned Pigeon occurs in the lesser Sunda and Kei Islands of Indonesia.

The range of the Brown Pigeon extends from Sumatra across Indonesia and the Philippines, through New Guinea, and into Australia, where it occurs from Cape York to southern New South Wales. The Black-banded Pigeon is found in monsoon forest and depauperate rainforest patches in gullies along the western edge of the Arnhem Land escarpment in the Alligator Rivers area of the Northern Territory, while the White-headed Pigeon, restricted to Australia, occurs in both rainforest and eucalyptus forest from Cape York to the Sydney region.

The Torres Strait Pigeon is distributed from the Andaman Islands westward over Indonesia and the Philippines, through New Guinea, and into Australia from Darwin, in the Northern Territory, along the northern cost and down the Queensland coast to Mackay. The Green-winged Pigeon ranges from India right through Indo-China and Indonesia to Australia, where it occurs from Darwin across the northern coast and down the east coast to southern New South Wales. (Map by K. Gregg).

present from September to January, and the Red-crowned Pigeon only from June to about November.

The favourite fruits of the Wompoo are those of Silver Quondong *(Elaeocarpus grandis)* and of several species of laurel. The Purple-crowned has similar preferences, but rarely takes Silver Quondong. The Brown Pigeon takes fruits of generally lower quality than those taken by the others. Celerywood (*Tieghemopanax* sp.) and Tobacco Bush *(Solanum mauritianum)* are of major importance to the Browns. The Red-crowned Pigeon has preferences intermediate between those of the Brown and the Purple-crowned Pigeons. Each of the other three species also has its specific preferences.

Australia's rainforests have declined steadily since settlement and are still doing so. Only tiny patches now remain of the once magnificent tract of subtropical rainforest known as the Big Scrub, in southern Queensland and northern New South Wales. All the way up the Queensland coast, the patches of rainforest have declined in area. The only relatively large tracts left are the tropical forests from Tully to the Daintree River. Yet even here, it is estimated, only 50 per cent of the original forest remains, and of the distinctive lowland forests a scant 10 per cent, centred on the Mission Beach area and scattered in patches north to Cairns. Clearing still continues.

There is a big conservation problem for our rainforest and its associated fauna, the fruit-eaters in particular. A large number of tree species which are often scattered over a wide area are needed to maintain pigeon populations, and this suggests that large areas of rainforest are needed for their conservation. Certainly, pigeons can move from one small patch of forest to another to feed, but there must be a lower size limit and a maximum distance between patches when they become unsuitable for pigeons. Mention should also be made of the Cassowary *(Casuarius casuarius)*. It is an obligate frugivore, but unlike pigeons, it cannot migrate too far in search of food. It needs large areas, or at least a clustered group of smaller areas with easy access between them.

Not only the physical area of rainforest, but also its quality must be considered in the conservation of our fruit-eating birds. Sufficient species diversity amongst the plants is needed to maintain a year-round supply of the right sorts of fruits. A problem arises in this respect regarding forestry activities. Normal logging procedures are probably not detrimental, and in fact may even be beneficial, to pigeon

A 'lone "Teak" (probably Gmelina leichhardtii), remnant of the rainforests near Dunoon, New South Wales. This forest was cleared about 1892, and this last tree died in 1972. (Photo: H. J. Frith).

populations. Many of the species used by pigeons, even some of the laurels, are important in secondary growth, which is stimulated after logging. Some practices, however, may be otherwise. Because many of the species of trees in rainforests are uncommercial, techniques aimed at increasing the representation of commercial species at the expense of uncommercial ones have been experimented with in many parts of the world's tropics. With few exceptions, the fruit trees used by pigeons are of uncommercial species, so forests treated successfully with these techniques are going to be poor habitat for fruit-eaters. At present, the situation is not acute in our northern forests which, for the most part, are managed on a natural regeneration programme, but as the demand for timber, especially the quality cabinet hardwoods, increases greater areas of forest will have to be made more commercially productive.

There are some very good national parks and reserves in the tropical Queensland rainforest, although the remaining lowlands forest is poorly represented in them, but whether they alone are big enough to support viable populations of all the fruit-eaters is not known. Let us hope that some relatively undisturbed forestry areas, managed so as not to reduce species diversity, will be left as well.

SALT-MAKING AMONG THE BARUYA PEOPLE OF PAPUA NEW GUINEA

By WILLIAM C. CLARKE and
IAN HUGHES

AS in all parts of the world, the people of the Papua New Guinea highlands greatly relish salt. Some highland communities have even introduced salt into ritual presentations, as well as using it as a valuable medium of exchange. It might be expected that as a highland people they would have obtained salt, as they did shells, from coastal dwellers, but such was not the case. Most highland groups and some lowland people made salt either by burning plant material or by evaporating water from salt springs, or by both methods.

In the simplest method of use, the ash of plant material — often fern — was eaten as salt, the desired flavour coming largely from potassium carbonate. This procedure could be carried out anywhere by anyone and was widely practised. Where there were saline springs, the water was often drunk or used for cooking; at some springs, it was evaporated to prepare a trade salt rich in sodium chloride. At a few springs the salt was extracted by soaking wood, and then drying and burning it, the salt-laden ash being the final product.

More elaborate methods that involved filtration and evaporation were carried out by some plant-salt specialists who selected or grew plants particularly for the purpose, and by one group of salt-makers at a saline spring in the central highlands. Salts from springs and some refined plant salts were highly valued beyond the region of manufacture and were traded over considerable distances. One of these was the plant salt made by the Baruya, a sub-group of the Kukukuku, or Anga, people who live in a valley in the Kratke Range in the vicinity of Wonenara in the Eastern Highlands District. Fortunately, it is still possible to observe their traditional process of salt manufacture, for the Baruya live in what remains a fairly remote part of the New Guinea highlands and still maintain the custom; and the product is still valued beyond their own community.

As the raw material for their salt the Baruya plant, in marshy valleys or irrigated spots, a tall grass that has been identified as *Coix gigantea* Koenig ex Roxb., a close relative of Job's Tears (*Coix lacryma-jobi* L.). When fully grown, the grass is cut during the dry season, dried for about a week, and burned, and the ash is then stored in a thatched-roof shelter. Both men and women collect and carry the grass, but only men engage in the ritually significant later stages of manufacture. When sufficient *Coix* ash has been accumulated, a filtering device is made outside the storage shelter. The heart of the device consists of a series of funnel-shaped gourds whose narrow bottom ends are packed with the spiny burs of *Triumfetta nigricans* F.M. Bail., a scrambling forest shrub. The plugged-up gourds are mounted in a row on a scaffold with their large, open ends upward. Beneath their lower plugged-up ends is a trough made from split bamboo stems or, in the case which we observed, the large leaves of what may have been a *Crinum* species. The trough drains into a bamboo carrying tube.

When this device is complete, the filter

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Garden of *Coix gigantea* Koenig ex Roxb. in a valley bottom. Irrigation is by simple diversion ditches.

The filtering process. A Baruya man pours fresh water into gourds partly filled with *Coix gigantea* Koenig ex Roxb. in a valley bottom. Irrigation is by simple diversion ditches.

The filtering process. A Baruya man pours fresh water into gourds partly filled with *Coix* ash.

The evaporator house, with the master saltmaker and a helper, who is bringing the banana leaves used to line the evaporating troughs inside the house. Bamboo tubes of salt water are to the left of the door.

The finished salt bars, before wrapping, lie in the foreground. The children relish loose flakes of salt.

operator partially fills each gourd with *Coix* ash, then pours in water from a bamboo tube. Watching the water-level in the gourds, the operator refills them as the water percolates through the ash and the *Triumfetta* bur filter to drip into the trough and drain to the bamboo tube. Initially, the drops of water coming from the gourds taste distinctly salty. Gradually, after several additions of fresh water, the salt content diminishes, and the filter operator, who has been tasting the percolate intermittently, empties the used ash and recharges the gourd with fresh ash.

When all the ash has been percolated, the process shifts to a small, isolated evaporator house, taboo to women while the manufacturing process is in operation. Inside the house, running almost its entire length, is a flat-topped ridge of the expended ash, which has been shaped into a series of transverse troughs, each about 27 inches long and about 6 inches wide. Underneath the troughs, running along the long axis of the ash ridge, is a tunnel lined with stones. Burning logs pushed through the tunnel heat the stones, which convey a gentle heat to the troughs. After lining the troughs with banana leaves to make them watertight, the salt-maker pours in the salty water produced by the filtering operation and carried to the evaporator house in bamboo tubes. As the heated water evaporates, leaving salt behind, the salt-maker adds further water until — after about a week of constant fire in the evaporator — a boat-shaped bar of greyish salt has formed in each trough. After the salt-maker has carefully extracted these, he wraps them in fresh banana leaves, strongly and attractively bound with strips of underbark from a common secondary-growth tree, *Trema* sp. Not all men are able to carry through this procedure; to be a salt-maker requires certain specialist magical powers or knowledge.

In the past, and to some extent even today, part of the salt is consumed and bartered within the Baruya group, whereas other bars are traded with outsiders. In 1972 a new bar, which weighed about 4½ pounds, was valued at $2 (Aust.) at the evaporator house. The French anthropologist Maurice Godelier, who has studied the Baruya, argues that traditionally the bars functioned as a primitive currency. In exchange for their "salt money", the Baruya acquired a number of necessities and luxuries not available in their own territory. For instance, they obtained the distinctive Anga bark capes by trading salt to a people living downvalley at an elevation where thrived the trees (probably a *Ficus sp.*) that provided good raw material for bark cloth. Other items that flowed back to the Baruya in return for their salt included black palm wood for making bows, pigs, shells, magical charms, and — before the coming of steel tools and Australian control — good stone blades and the stone heads for war clubs, suitable stone not being available in the limestone Baruya country.

Exactly how far Baruya or other Anga salt travelled in pre-European times is uncertain, but their product was highly valued and one of the most widely dispersed salts in the eastern part of the highlands. Being wholly a plant salt, it was different in composition from the salts from saline springs. Chemically, a typical Anga salt was 65 per cent potassium sulphate, 19 per cent potassium carbonate, and 15 per cent potassium chloride. In contrast, a typical salt-spring type, from the Wahgi Valley, was more than 75 per cent sodium chloride. In the eastern part of the highlands plant salts were the most traded salts, though a little sodium salt was also made. In the western part of the highlands many plant salts were made and exchanged locally, but sodium salts had the largest trade areas, some travelling up to 60 miles from the salt-makers; they also commanded the highest exchange value for acquiring pigs and shells.

The continued popularity of locally made salts (even when there came to be no shortage of commercial table salt), the big trade in some plant salts such as the Baruya's, and the variety of spicy leaves and roots eaten in association with the salts on festive occasions all suggest that in their salt-making and trading the highlanders were meeting a desire for distinctive condiments rather than trying to satisfy physiological needs. In each cultural milieu across the country, the particular product which occupied pride of place as a condiment depended on availability, habituation and custom. Scarcity, cost and the social importance of the occasions when it was eaten — ranging from simple commensality between kinsmen to huge ritual feasts of tribes — all served to establish the position of particular salts as characteristic traits of local cultures.

(*The photos in this article are by William C. Clarke.*)

Maurice Godelier describes the Baruya and their salt trade in "La 'monnaie de sel' des Baruya de Nouvelle-Guinee", *L'Homme*, 1969, vol. 9, no. 2, pp. 5-37. Another description is to be found in "Salt Making in Inland New Guinea", by A. Freund, E. Henty, and M. Lynch, in *Papua and New Guinea Scientific Society Transactions*, 1965, vol. 6, pp. 16-19.

THE CASE FOR A BUSH GARDEN

By JEAN WALKER

Looking from the ki chen window to th new bush garden — a area of lawn in 1967 (Photo: C. V. Turner).

Only six years ago there were few native gardens in Sydney, and these were not designed as natural gardens but largely to demonstrate a range of unusual species. The concept of a natural garden was entirely new when the book *Designing Australian Bush Gardens*, by my sister Betty Maloney and myself, was published. In fact we thought our book would never really sell, because people wanted azaleas and roses and camellias — a garden usually had a lawn in the middle, and the bush merely made a useful background. Native plants were considered rather commonplace and temperamental, and died readily. Little or nothing was taught about them in schools, they had difficult names, and when sold in shops they not only looked like weeds but were expected to be more or less free.

Now, however, it is quite the fashion to have a bush garden and, amazingly, the plants thrive! Supermarkets have special sections for bush plants, even for "ground covers", at one time scarcely known. People are asking "Is this one a native?" Nurseries have difficulties in keeping up supplies, and the demand for seed is overwhelming.

The idea of "naturalness with order" has been kindled — the idea that a bush garden can be a retreat, a back-to-nature thing, even a spiritual adventure. "Throw away the lawnmower, put out the chairs, and smile benevolently at everyone. With maintenance at a minimum one's only responsibility is to appreciate."

JEAN WALKER studied art at Melbourne Technical College, graduated from the Melbourne Teachers' College, and taught in the Victorian Education Department and at Melbourne Grammar School. Mrs Walker worked under Alec Blombery at Stony Range Flora Reserve, Brookvale, Sydney, and, with her sister Betty Maloney, is co-author of *Designing Australian Bush Gardens* and *More About Bush Gardens*. She has had two successful art exhibitions in Sydney, with the Australian bush as a theme, and is represented in private collections in England and Australia.

In the bush, peace and tranquility begin on the ground. It is only necessary to stand beneath the trees and break up fallen sticks. Gumleaves are on the ground for a purpose — and how beautiful! People are buying wood chips, sawdust, bark, almond husks and circles of wood. They are collecting leaves and needles in bags, and spreading them thickly over the ground. No digging is needed, no weeding (or very little) and certainly no mowing. No more arduous watering programme all through summer, and no incinerating on Sundays. Holiday problems are over.

A true bush garden will offer the most perfect and delightful welcome; all one must do is make it comfortable to be in. Bring to it the simple, timeless things of the bush that are soft and quiet and safe to tread on: cobbles of stone laid in patches of sunlight, comfy brown bricks in mossy cool shade, shaggy old logs laid among carpet of leaf and twig, soft bark in places where children can play, smooth crumbly pebbles for car drives, strange patterns of lichen on boulders stacked among ferns. All these things under the raggedy bright light which filters down through the branches of the gum trees. Roberts and Gruner painted this long ago. Here the little creeping pine, long since turned to stone in some countries, can at last remain safe and sheltered. Precious wild flowers that money simply cannot buy will bloom for you. Go out and hang an old lamp in the knobbly branches of the primitive *Banksia* tree, and put your chairs beneath it. A bush garden is more than a garden, it is a way of life. Somewhere to be alone, to be in the sun, or to find a quiet cool place with friends at the end of the day.

Sir Mark Oliphant writes: "In a country with the low and erratic rainfall of Australia and the high evaporation, a lawn is a luxury which we cannot afford. Yet still, in the capital cities, lawns cover large areas, at great cost in watering and attention generally." Couch, kikuya and buffalo grass, and their accompanying

Water ferns. *Blechnu lanceolatum* has fron up to two feet high. *minus* can develop in a large rosette. *B. ca tilagineum* (grist fern) fronds may gro three feet high. (Draw ing by the author).

retinue of weeds, are disastrous in our bushlands. Most of them root at every node and very quickly exhaust the delicate micro-organisms in the leaf litter. The constant cutting of lawns quickly impoverishes the soil, for grass, mower and rain all weaken and undermine the natural food-cycle.

When we have need for small, open, sunny places in our parks and gardens it is infinitely cheaper, far less time-consuming, and more lasting to do away with lawns completely. Councils are only now beginning to understand. They are using wide pavings as breaks between a field of grass and virgin bush. On the grassy side the pavings are usually kept straight or simple, but on the bush side the countour is deliberately left informal. Sad to say, it is still considered a waste of time and a bit of a joke to weed the bush. One day developers and planners will regulate their activities with very strict rules for the protection and maintenance of the natural landscape.

For practical reasons it is best to select ground covers that are found in your nearest bushland area. The whole floor of a garden can be clothed most beautifully with ferns. Visit the bush and see how frequently they appear. There is an astonishing variety; they are disease-resistant and quite easy to grow. Remember, nothing grows naturally in straight lines, and ground covers can weave between brick and stone patterns most delicately.

ınksia serrata may ɔw 10 feet in three ars. Grass Tree *(Xan-orrhoea)* is reputed to ɔw only a foot in a ntury. *Casuarina* can ɔw six feet in its cond year. (Drawing the author).

Fishbone fern is rampant in old suburban gardens (identify it by the spheroidal tubers) and has helped to prejudice people against the gentler native ferns. It is a great pity that the fern *Culcita dubia* has been mistakenly condemned as bracken. *Culcita* has a paler, lacier frond, and a light-brown velvety foot which is readily controlled. It luxuriates around the trunks of trees and boulders. Hillsides can be curtained with its cascading green veils.

Tree ferns are very simple to grow if there is a little moisture. They are the brides of the forest; in my small garden I have seventeen. Maiden hair is quite hardy when once established. Its first tender green frond is loved by snails and slugs, so watch for them when you start to transplant little pieces for your glade. The little native violet will ramble daintily and flower for almost the entire year. It may become rampant — which is delightful — if you are a busy person.

Remember, nature has mended the broken soil for centuries past, tilling without any help from

Native ferns readily establish in mulch; require no maintenance.

you. You will not have to dig any more. However, if there are weeds don't expect the bush to weed itself.

With just a little love and imagination we can create new wonders with all these glorious plants and trees and the fabulous Australian topography at our disposal. The possibilities are overwhelming.

Somewhere near the city, perhaps a slum area could be transformed. Why not a thunderous forest of tall white gums with smooth and shiny trunks, like great Greek columns? Make an inner courtyard by removing the central trees. Pave it with rings of wood or stone, and invite special guests to boil the famous billy. And clothe the forest floor with ferns. Hopefully, in another decade or even less whole cities will have changed, and whatever is ugly will be transformed dramatically by this new awareness of our own landscape. If we could follow nature's ever-perfect example, its infinite ability to produce "good design" to "do the right thing every time", we would be astounded by our previous blindness.

FURTHER READING

Blombery, A. M. *A Guide to Native Australian Plants*, published by Angus & Robertson Ltd., Sydney.

Bradley, Joan. *Bush Regeneration*, published by the Mosman Parklands and Ashton Park Association.

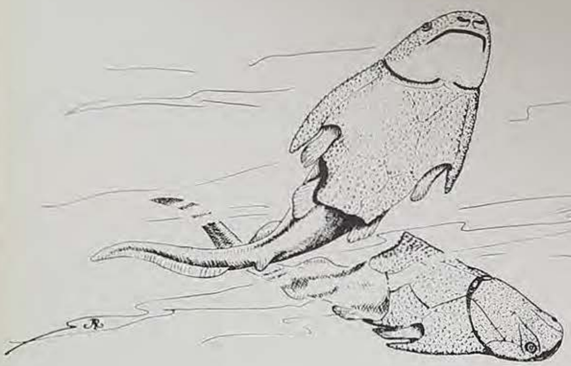
Above: established *Angophoras* in the new bush garden — once a lawn — viewed from the kitchen window. Middle: boulders once covered with lawns. To holiday for six months presents no problem! Below: native violets have replaced mortar. (Photos: Author).

Above: river pebbles and tree sections provide an attractive floor. Middle: railway sleepers and fallen leaves avoid the need for cement. Below: native violets now ramble between exposed boulders, flower for nine months of the year. (Photos: Author).

"FROM GREENLAND'S ICY MOUNTAINS . . ."

— a detective story in stone

By ALEX RITCHIE



Tentative reconstruction of *Groenlandaspis*.

"There came a surge of triumph — the triumph some specialist might feel who has successfully reconstructed an extinct animal from a fragment of jawbone and a couple of teeth." — Agatha Christie.

The belief that a palaeontologist can reconstruct a long-extinct animal from a few scraps of bone is a commonly held misconception. On the other hand there is no denying the excitement, satisfaction and even occasionally the feeling of triumph which one experiences as the various pieces of a fossil jigsaw begin to fall into place to form a coherent pattern.

ALEX RITCHIE, Curator of Palaeontology at the Australian Museum since 1968, was born and educated in Scotland. After studying geology and zoology at Edinburgh University he lectured in geology at Edinburgh and Sheffield Universities. Dr Ritchie is interested in the early evolution of vertebrates and is currently studying Ordovician remains from Australia, Silurian ostracoderms from Europe and various Devonian fishes from Australia, Antarctica, Europe and Greenland. In 1970-71 he was a member of a New Zealand university expedition to South Victoria Land, Antarctica, and the Devonian fish collected on that occasion have since led to an unexpected chain of discoveries on four continents, as described in his article in this issue.

The story behind the seach for, and reconstruction of, animal remains from the distant past often contains the basic elements of detective fiction at its most exciting; let me illustrate this by relating the unexpected sequence of events which have recently led to the discovery of a distinctive type of fossil fish on four widely separated continents, in sedimentary rocks laid down in late Devonian times, about 350 million years ago. Although some of the first clues turned up in Ireland and England in the 1850's and 1860's and in the Antarctic about 1911, the story really begins in the early 1930's in East Greenland.

Scandinavian expeditions to the mountainous east coast of Greenland have discovered many rich and scientifically important fossil deposits in rocks of Devonian age. These contained the remains of a large variety of primitive forms of armoured fishes together with the skeletal remains of the oldest known four-footed animals, primitive amphibians. These first land animals, *Ichthyostega* and other amphibians, came from near the top of the Devonian sequence, from a formation known as the Remigolepis Series. *Remigolepis* is a distinctive type of armoured fish which also occurs in Australian rocks of the same age

Overlying the Remigolepis Series in a few isolated mountain-top sites in Greenland is another formation, the Groenlandaspis Series, the youngest Devonian sediments known from East Greenland.

This formation was also named after an unusual type of armoured fish known from only a handful of detached and incomplete bony plates. The first specimens to be discovered were described in 1932 by Professor Heintz, of Oslo, and named *Groenlandaspis*, a name meaning "Greenland shield". Some later finds were described by Professor Stensiö, of Stockholm, between 1934 and 1939, and a single plate discovered in 1954 was described 10 years later by Dr Miles, of the British Museum (Natural History).

Unfortunately there was still not enough material to allow a reconstruction to be made but it appeared that *Groenlandaspis*, possibly the last surviving representative of the armour-plated arthrodiran fishes, was most closely related to a primitive group which reached its peak in Lower and Middle Devonian times. Despite intensive research into Devonian fishes since the 1930's no more definite remains of *Groenlandaspis* came to light for almost 40 years, and then they turned up virtually on the opposite side of the world, in Antarctica.

Fragmentary remains of Devonian fishes were first recovered from the Antarctic continent by members of Scott's last ill-fated expedition in 1911. Almost half a century later some New Zealand members of the 1957-59 Commonwealth Transantarctic Expedition found the first fish fossils in place in the rocks of Southern Victoria Land. Then in 1968-69 another New Zealand team, Victoria University of Wellington's Antarctic Expedition No. 13 (VUWAE 13), collected a considerable quantity of material from the same area; this material was sent to me to study in the Australian Museum. Since early 1968 I had been investigating rich fossil fish deposits in the Devonian rocks of western New South Wales, and it was hoped that some links might be discovered between the Australian and Antarctic faunas.

The Antarctic fish remains recovered by VUWAE 13 proved so interesting that it was decided to send another expedition into the same area in the 1970-71 season, but VUWAE 15 differed from the earlier field parties in that it included myself and a colleague, Mr Gavin Young, from the Bureau of Mineral Resources in Canberra, as the first vertebrate palaeontologists to visit that part of the Antarctic continent.

For over two months, despite vehicle breakdowns and bad weather, our team searched the isolated mountain ranges of Southern Victoria Land for likely fossil fish sites, with considerable success. A general account of our discoveries was given in *Australian Natural History* (1971, pages 65-71), but at that time, before very much of the fossil material had been cleaned up and painstakingly prepared, we were unable to identify many of the specimens with certainty. As preparation proceeded it slowly became apparent that a considerable proportion of the disarticulated and often broken skeletal remains could be allocated to one particular type of armoured fish, one of a group known as arthrodires (a name meaning "jointed-neck") from the distinctive ball-and-socket articulation between their head and trunk armour covering.

We had brought back one almost complete and several partial headshields of this strange fish, together with numerous dissociated specimens of the various bony plates which originally comprised the trunk armour. A search was made through the scientific literature to see if such a form had ever been recorded from rocks of comparable age in other parts of the world, but at first without success. It appeared that this Antarctic Devonian arthrodire might be new to science.

Alex Ritchie driving a Polaris snowmobile in the Southern Victoria Land, Antarctica. The 8,000-foot Warren Range is in the background.


Then, as preparation progressed and we had sufficient material to attempt a complete reconstruction of the fish, it became obvious that our Antarctic fish showed distinct affinities to the poorly-known, late Devonian form, *Groenlandaspis,* known only from far distant Greenland! However, before the new Antarctic material could be positively identified it was essential that it be compared at first hand with the Greenland discoveries, so plans being made for a study tour to Europe and North America were broadened to include the examination of *Groenlandaspis* material and other relevant forms in the various large museum collections of Devonian fish fossils.

In the meantime there had been other interesting developments within New South Wales itself which were to be clues in the search for *Groenlandaspis.* In early 1972 a very rich, late Devonian fish deposit was uncovered in a quarry along the Jemalong Range, west of Forbes, in central New South Wales. It was discovered by a young student from the Australian National University, Canberra, Mr Morris Bell, during a mapping project. Mr Bell collected a large quantity of well-preserved remains of *Bothriolepis* and *Remigolepis,* strange armoured fishes characteristic of the Upper Devonian, most of them from loose blocks in the quarry.

I then decided that we should excavate more material from the same layer exposed in the face of the quarry. Since this would obviously involve a major effort requiring both manpower and excavation equipment, I realised it presented an ideal opportunity to take up a long-standing offer of assistance from no less a body than the Australian Army! The Army had previously approached the Museum with a suggestion that they could provide men, vehicles, equipment and all back-up facilities for a Museum expedition where such support might be of use. In this way the Museum would get the logistic support and the troops would get an unusual form of "adventure training".

To cut a long story short: in May 1972 my preparator, Ian Macadie, and I joined up with some 20 infantrymen of the 5th Battalion, Royal Australian Regiment, led by Major Rollo Brett and Captain Eddie Windsor-Clive, and set out for Forbes to excavate the Devonian fish site at Jemalong. The "exercise" lasted about five days during which period a large area of the fossil fish layer was uncovered by jackhammers and removed in large blocks to the army lorries to be transported back to the Australian Museum.

By far the most common fossils in the Jemalong material were isolated bony plates from the armoured skeleton of *Bothriolepis* and *Remigolepis,* both of which were known to be locally abundant in rocks of the same age in East Greenland. *Bothriolepis* has also been found in many other parts of the world, including Antarctica and Australia. Another link with Greenland was provided by a single specimen of a skull of a long-headed lungfish, collected by Mr Bell in the Jemalong quarry. This was identified as *Soederberghia,* until then only known from the East Greenland rocks. The Jemalong material was found to contain, as a minor element in the fauna, occasional small arthrodire plates which, at the time, could not be positively identified. Their significance did not become apparent until almost a year later.

On the return journey to Sydney Ian Macadie and I diverged from the Army convoy to investigate another reported Upper Devonian fish locality to the north of Grenfell, also in central New South Wales but some 40 miles away from the Jemalong site. Our brief reconnaissance confirmed that the site showed considerable promise; we collected a few specimens from the surface and brought them back to the Museum for preparation and closer examination. The Grenfell material is usually preserved in such a way that the bony plates are broken through the middle and can only be identified after the bone has been removed to leave a natural mould. From this one can take a rubber latex cast which shows even the finest detail. The reader may imagine our surprise when the Grenfell material proved to contain three separate plates with the diagnostic characteristics of the genus *Groenlandaspis!* This was the first time that *Groenlandaspis* had been positively identifed in Australia, and the exciting discovery, extending its known range to a third continent, obviously placed the Grenfell site high on our priority list of fossil localities to be investigated and excavated.

Unfortunately this was not possible until the following year, after the completion of my comparative studies in European museum and university collections. Research into early fossil vertebrates has for a long time been carried out mainly in Northern Hemisphere institutions, and Australian museums have generally lacked either the specialists in the field or the large collections of comparative material which overseas workers have built up. Thus it was only by visiting collections such as those in the

Fine specimen of a median dorsal plate of the new species of *Groenlanaspis,* from Grenfell, New South Wales, seen from the left side.

Chris Jenkins, a member of the Australian Museum Discoverers' Club, and Robert Jones, a preparator in the Museum's Palaeontology Department, examine the first median dorsal plate of a new species of *Groenlandaspis* immediately after its discovery at a site north of Grenfell.

British Museum and in Oslo and Copenhagen that I could positively identify my Antarctic and Australian material.

The confirmation that we had, indeed, discovered *Groenlandaspis* was not unexpected — what *was* unexpected was the discovery of undoubted *Groenlandaspis* material in European collections, from sites in Europe, the first record of the genus from that continent.

During the course of a brief visit to Bristol University, England, in late January 1973 (to look at new Canadian fossil fish material quite unrelated to the *Groenlandaspis* story) I took the opportunity to browse through the small museum collection in the Department of Geology. There, amidst a varied assortment of small fish plates, spines and scales from an Upper Devonian site on the shore on the Severn estuary, a few miles west of Bristol, were arthrodiran plates with all the distinctive features of *Groenlandaspis*, although from a smaller species than any of the other occurrences. It later emerged that the site, near Portishead, had been known since the 1850's, although the University material had been slowly accumulated since the 1930's by a former member of staff, Mr Tom Fry, in the course of numerous visits to the Portishead fish bed.

Less than a week later, in early February, I was in Cambridge working through fossil collections in three museums. The first two contained little of particular interest for the work in hand, and at first sight the third collection, that of the Sedgwick Museum in the University of Cambridge, seemed equally unproductive. Then, out of the blue, and tucked away in almost the last drawer of specimens to be examined, I came across a small collection of greenish-grey rocks, each bearing one or more arthrodiran fish plates or fragments preserved in a blackish substance. Once again the diagnostic features of *Groenlandaspis* were present, but neither the lithology nor the preservation of the fish plates showed the slightest resemblance to the Bristol occurrence. It was immediately obvious that I had stumbled on yet another

Gavin Young (centre distance) searches for fossil fish in the Devonian rocks on the east flank of Portal Mountains, Southern Victoria Land, Antarctica.

occurrence of the now widespread genus, *Groenlandaspis*, the second from Europe and both recognised within the same week!

There was one major problem. The Cambridge specimens were not only unidentified — they were also unregistered and unlocalised! Although they carried specimen numbers these were *not* Sedgwick Museum numbers but were obviously those of the original collection from which they had been acquired, probably back in the nineteenth century. A search through the Museum's records failed to uncover any information as to when, how or whence they had come to the Sedgwick Museum. It seemed that I had reached a dead-end — until a clue emerged the following week during discussions with Professor T. S. Westoll in the University of Newcastle.

According to Professor Westoll, the Cambridge *Groenlandaspis* material, from its description, showed some resemblances to a known Upper Devonian fossil fish occurrence from the south of Ireland. Originally discovered in the early 1850's, the Kiltorcan Beds of the country of Kilkenny, Eire, have long been famous for their wealth of beautifully preserved fossil plant remains which had to some extent drawn attention away from the associated fossil fish remains from the same beds. Some of the fish material was tentatively identified about 1860 as belonging to genera of Upper Devonian fish known elsewhere at that time *(Bothriolepis, Pterichthys, Coccosteus,* etc.) and a very brief description had been published in 1891 of the *"Coccosteus"* as *Coccosteus disjectus* Woodward. This was generally accepted until 1968, when Professor Westoll and Dr Miles, now of the British Museum (Natural History), had shown that *Coccosteus disjectus* was not a true coccosteid but some other form of unidentified arthrodire.

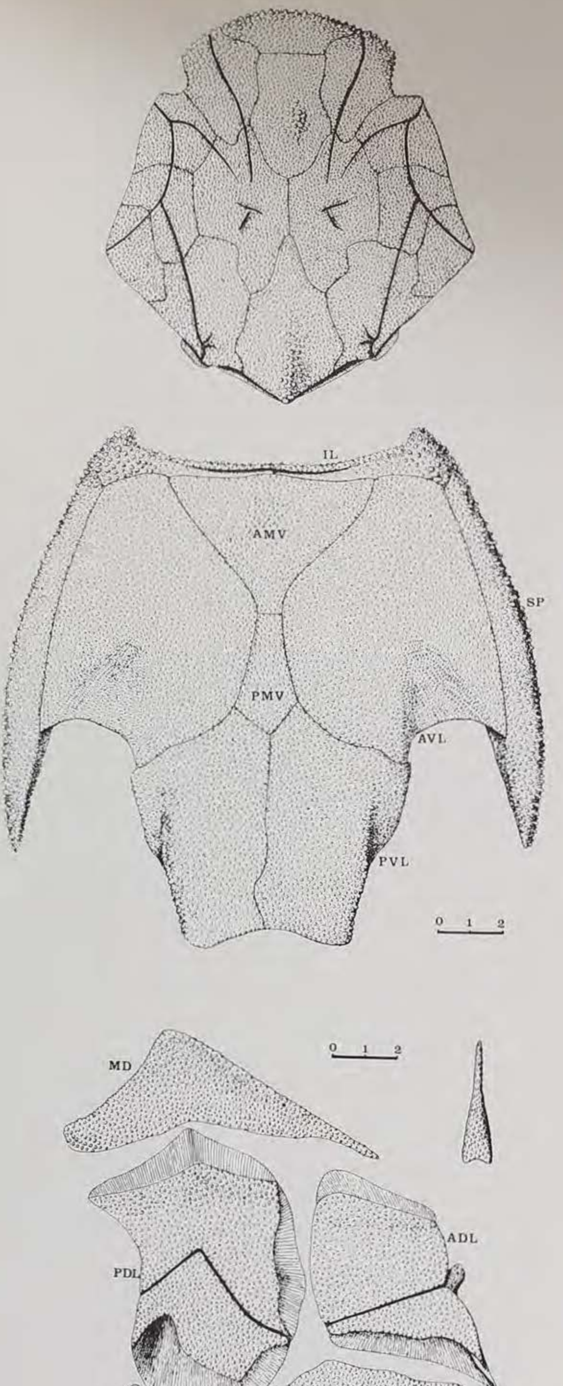
The next scheduled stop in my study tour was the Royal Scottish Museum in Edinburgh, which was known to possess a small collection of fish remains from the Irish Kiltorcan Beds. It took only a few minutes to locate these in the collections and confirm immediately that the Edinburgh and Cambridge material had obviously come from the same source. Not only were the remains those of *Groenlandaspis,* but the Edinburgh specimens still bore the same original type of collection number, which proved to be the numbers of the Irish Geological Survey that had presented them to the Edinburgh museum before 1870!

The trail now led, obviously, to Ireland. If the Irish Geological Survey had given away so much good fossil material to two collections in England and Scotland it seemed almost inconceivable that they had not retained at least as much again in their own collections. A hurried approach was therefore made to Dublin, and Dr Ralph Horn, of the Irish Geological Survey, quickly confirmed that they did still hold a considerable quantity of the original Kiltorcan material but that the plant, molluscan, arthropod and fish fossil material was all stored together, sometimes with several specimens preserved on the same slab. There seemed no alternative but to squeeze a quick visit to Dublin into an already tight programme, and in April 1973 I spent three hectic days sorting through all the Kiltorcan material in the Survey cellars, extracting the fish material and, perhaps more importantly, checking through all the old registers. The latter contained a wealth of information which revealed that between 1858 and 1861, when the Survey collectors had actively quarried the Kiltorcan Beds for their fossil plant and animal remains, some 400 specimens of fish plates had been registered (although many of these were counterparts of other specimens in the collections).

During November and December 1861 the Survey staff had separated out large and representative samples of this Kiltorcan fauna and flora and sent them off to other university and museum collections in no fewer than eight cities — Cork, Galway, Belfast, Dublin (Trinity College), Edinburgh, Cambridge, Oxford and to what is now the Institute of Geological Sciences in London.

Using this information, I have since been tracking down the present whereabouts of this dispersed material, with considerable success, and we can now be certain that not only is Woodward's *"Coccosteus disjectus"* really a *Groenlandaspis,* becoming *Groenlandaspis disjectus* (Woodward), but that nearly all of the other fish plates in the Kiltorcan fauna belong to this same species. *Groenlandaspis disjectus* can now be reconstructed almost in its entirety, and compared in considerable detail with the other known species of *Groenlandaspis*.

Far from being finished, however, the search for *Groenlandaspis* is still turning up new surprises. With the wealth of new material at our disposal it is now clear that we can trace the *Groenlandaspis* line back as far as the Lower Devonian some 30 million years earlier because a small, rather unusual arthrodire named



Tiaraspis, from the Lower Devonian rocks of Germany, Belgium and Spitsbergen, displays virtually all the features one might expect in an ancestor of *Groenlandaspis*.

On my return to Australia in May 1973 I was keen to revisit the site near Grenfell as soon as possible, knowing that with a bit of luck we might get much more material of the new *Groenlandaspis* species discovered there the year before, the only one known at that time from Australia. Again we had an offer of assistance, not this time from the Australian Army but from members of the Australian Museum Discoverers' Club, keen teenagers with an active interest in various aspects of natural history. So, over a long holiday week-end in June 1973, the Grenfell site was closely examined and intensively excavated by a team consisting of myself, my new preparator Robert Jones (and his wife), two Museum education officers and seven boys and girls of the Discovers' Club (their ages ranging from 17-21). The venture was extremely successful, and approximately half a ton of fish-bearing rock, much of it in large blocks, was extracted and carried down a steep hill to the camp-site. Subsequent preparation of this material has revealed not only many beautiful examples of the characteristic plates of the *Groenlandaspis* armour but an assortment of other fascinating material, some of which appears to be quite new to science.

At the same time, using newly-acquired preparation facilities in the Australian Museum, we started to prepare the large blocks of fish-bearing rock collected by the joint Museum-Australian Army team from the Jemalong Range in 1972, and to our surprise — and delight — we quickly established that the "small unidentified arthrodiran plates" mentioned earlier represented yet another small species of *Groenlandaspis*, quite distinct in every way from the Grenfell form found only 40 miles away. Without realising it at the time, we had collected *two* new Australian species of *Groenlandaspis* in the same week of fieldwork.

In spite of all these exciting discoveries which had come to light in such a short space of time, there remained a problem of finding the link between the little Lower Devonian *Tiaraspis* from Germany and the much later Upper Devonian species from Greenland, Ireland, England, New South Wales and the Antarctic. If the *Groenlandaspis* lineage had been in existence for all this time it seemed probable that a Middle Devonian representative must surely turn up

Trunk armour plates of *Groenlandaspis* spp. from Antarctica, Australia and Ireland. A fine median dorsal plate (MD), seen from the right side, comes from the Aztec Silk Stone of Southern Victoria Land and Antarctica; the other two plates are right posterior dorsolaterals (PDLs) from near Grenfell, New South Wales (on left), and Kiltorcan, Southern Ireland (on right).

eventually. It was only then that I realised that the solution lay in our own collections.

Since late 1968 my assistants and I had been collecting abundant material of disarticulated arthrodiran remains from sites in western New South Wales (*Australian Natural History*, 1969, pages 218-223). The bulk of the fish remains are derived from only two genera, both of them new, but at the same time we have been slowly accumulating isolated plates and fragments derived from several other arthrodires present in the same fauna but in much smaller numbers. Until recently we have been unable to do very much with them, but during 1972-73 it became apparent that this material contained at least one form closely related to *Groenlandaspis*. The Mulga Downs Group from which they come is now thought to be at least partly Middle Devonian in age, and we thus have an arthrodire, of approximately the right age, which is in many respects intermediate between the Lower Devonian *Tiaraspis* and the Upper Devonian *Groenlandaspis*.

These findings, when prepared, documented and published, will be of interest not only to specialist workers interested in the rather esoteric field of long-extinct fish but to others working on aspects of continental drift and plate tectonics, and to those interested in correlating rock successions not only within continents but between continents. I was unable to follow my research work through to the various North American museums and, in the light of what has now been discovered concerning *Groenlandaspis* and its relatives, it would be surprising if more discoveries of this once very rare and localised but now almost ubiquitous Devonian fish do not come to light. There are large Devonian fish collections from the Baltic area and in Russia and in China, as well as those in North America, and there is a strong possibility that more *Groenlandaspis* material is lying somewhere in fossil collections awaiting recognition.

The search for this strange and long extinct fish has also involved the efforts of innumerable other people — a truly international cast ranging from the members of the New Zealand Antarctic research programme and the U.S. Navy aircrew who ferried us to and from the isolated Antarctic sites, to the men of the Royal Australian Regiment, the teenagers of the Museum's Discoverers' Club, the nineteenth-century Irish and English fossil collectors and the Scandinavian geologists who spent many seasons searching "Greenland's icy mountains".

So the exciting, and continuing, story behind the search for *Groenlandaspis* and its discovery, so far, on four widely separated continents serves to illustrate rather nicely my earlier remarks concerning the similarities between palaeontological research and the best elements of good detective fiction.

Professor George Gaylord Simpson summed it up very nicely when he wrote:

"To those who follow it, the pursuit of fossils is more exciting and rewarding than any pursuit of living fish, flesh or fowl. It has all the elements of skill, endurance, suspense and surprise; and the resulting trophy may be a creature never before seen by man."

(Financial support for Dr Ritchie's research work in Europe was provided by the Bushell Trust, the Ian Potter Foundation, the Science and Industry Endowment Fund of the C.S.I.R.O., and the British Council. The Australian Research Grants Committee has provided funds to employ a full-time preparator on the project since 1971. This assistance is gratefully acknowledged.)

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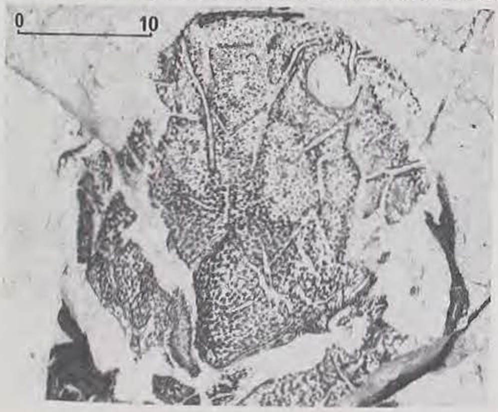
A new species of *Groenlandaspis* from the Upper Devonian of Southern Victoria Land, Antarctica. Reconstructions of the head shield (top), the ventral surface of the trunk armour (centre) and plates of the dorsal and lateral trunk armour, shown separated (bottom). Abbreviations of the various plates are as follows: ADL, PDL — anterior and posterior dorsolaterals; AL, PL — anterior and posterior laterals; AMV, PMV — anterior median ventrals; AVL, PVL — anterior and posterior ventrolaterals; IL — interlateral; MD — median dorsal; SP — spinal.



An almost complete head shield of *Groenlandaspis* (formerly *Coccosteus disjectus* Woodward), with the anterior margin at the top and one orbit clearly visible (top right).

BOOKS

LIFE BEFORE MAN, by the editors of "Time-Life Books"; Time-Life International (Nederland), 1973; 160 pages; $6.95, plus 70c postage, from Time-Life Books, Sydney.

Life before Man is the first in a series of *Time-Life* books on the theme "The Emergence of Man". This first volume sets the scene for the others, and is attractively produced and reasonably priced. It starts with a look at "the paragon of animals", an interesting account of the nature and basic characteristics of man in relation to some of his contemporaries. We are then taken back to the other end of the time scale, some 3,500 million years ago, when the first recognisable organisms made their appearance on earth. The evolution of plant and animal life to the present day is covered briefly, with attractive reconstructions of some animals of the past; and this is followed by a fine selection of interesting fossil specimens. These are beautifully photographed in colour to illustrate the diverse ways in which organisms have managed to become preserved as fossils — the delicate impression of a butterfly's wings contrasts with the almost perfect preservation of an ant in amber, while we see the skeleton of a 14-feet long, 100-million-year-old fish with another 4-feet-long fish inside its ribs, the remains of his last (and too ambitious) meal.

Evolution and extinction go hand in hand, and the book takes a look at "nature's grand failures", notably the spectacular array of giant reptiles we call dinosaurs, which roamed the earth for some 150 million years. Some of the most interesting stories of the discovery of dinosaur skeletons are retold, with amusing contemporary illustrations. The authors discuss how dinosaurs lived, walked and obtained their food — and the unsolved enigma of their disappearance.

The latter half of the book illustrates the ways in which we can trace the skeletal and soft structures of the human body back to their origins in the reptilian or even the fish condition, 350 million years ago. This section is clearly illustrated by readily understandable figures in several colours. The book ends with an account of the gradual development of more and more complex organisation in life forms, beginning at the cellular level and leading eventually to the complex societies and behavioural patterns of advanced organisms, ranging from termites to man himself.

Life before Man can be recommended to most readers of *Australian Natural History* with one reservation — and an important one. Throughout the book the generic names of animals and plants are used without capitals, italics or heavier type as is customary in scientific literature. Even worse, there are some strange inconsistencies. *"Homo sapiens sapiens"* (page 9) gets the full treatment, but elsewhere we read of one of his ancestors, "the aegyptopithecus" (page 46). A well-known form of extinct marine reptile is correctly referred to as *"Ichthyosaurus"* (page 73) and only two lines afterwards reappears as "ichthyosaurus". Non-specialists will find it difficult to distinguish betwen scientific names and common names, e.g., "the huge arsinoitherium", and "the rhinoceros". It is an unfortunate lapse in editing, and it is to be hoped that it will be remedied in later editions and volumes in the series. — *Alex Ritchie, Curator of Fossils, Australian Museum*

ANIMAL PARASITES, by Jean G. Baer; World University Library, London, 1972; 255 pages, 66 diagrams, 44 photographs in colour and black and white; bound edition $6.45, paper edition $3.10.

Professor Jean Baer has an enviable reputation amongst parasitologists throughout the world as a research worker and author. One has come to expect work of merit from him, and again one is not disappointed. However, in this particular book, lacking as it does a preface, the author's objectives and the intended readership are not stated and are not entirely clear after examining the text. If the book were aimed at biology students, then it is a success, being in some ways an up-dated version of Baer's interesting and informative book of 20 years ago, *The Ecology of Animal Parasites*. If, on the other hand, the author had an enthusiastic amateur readership in mind, the inclusion of coloured illustrations and photomicrographs are unlikely to sustain such a reader through the terms, scientific names and life-cycles referred to in the text. The first two chapters do steer a newcomer to the field towards some of the important concepts, but hardly prepare him for the detail encountered in late chapters (for example, Table 3 (a) on the monoxenous cycles of nematodes).

The book has many commendable features. A comprehensive selection of examples from the major groups of parasitic animals permits a broad appreciation of the fascinating variety of parasitic habits and habitats. There is also meticulous attention to detail, and there are some interesting photographs of parasites not widely published. A series of colour photographs on page 149 of a trematode infection in the tentacles of a snail is especially interesting.

Packed into the 250-odd pages of this book is much useful and interesting information; for those who want to know more, the bibliography for each chapter will no doubt be a help. — *Edward S. Robinson, School of Biological Sciences, Macquarie University, Sydney.*

FACES OF NEW GUINEA and WIGMEN OF PAPUA, by James Sinclair; the Jacaranda Press, Milton, Queensland, 1973; recommended price, $4.95 each.

After 25 years in Papua New Guinea, spent mostly in the Highlands, James Sinclair has a vast fund of experiences and photographs that so far have filled seven books and, one hopes, several more to come. These latest two contributions follow the style of his last book, *The Highlanders*, relying on the power of photographs rather than text to present the subject matter.

Faces of New Guinea consists almost entirely of illustrations, all in colour taken on the old Kodachrome ASA 10 film, with a minimum of text. The subject is literally what is indicated in the title. Personally I find this volume rather dull and static, though it will be valuable as a record of self-decoration around the various areas of Papua New Guinea.

The Wigmen of Papua has a brief text of historical interest summarising the main events in the establishment of Government control over the Huli and Duna areas, in the Southern Highlands of Papua. The story may have been told more fully and better elsewhere, but the photos of actual patrol work are of great interest.

The author does not pretend to be presenting anthopological studies, and indeed they are not. But as photographic studies, they are eminently successful and useful additions to the popular literature on Papua New Guinea. Perhaps the time will come when anthropologists will abandon the turgid prose of professional publications and provide texts to support Sinclair's illustrations. — *Jim Specht, Assistant Curator of Anthropology, Australian Museum.*

AUSTRALIAN INSECT WONDERS, by H. Frauca; Rigby, Ltd., 1973; 147 pages, illustrated; $3.95.

This is an enlarged version of an earlier work entitled *Harry Frauca's Book of Insects* — which has gained nothing by being enlarged. This can only be considered a somewhat mediocre addition to bulk so far as Australian natural history literature is concerned.

There has been a considerable and commendable increase in interest in the natural history of this continent over the past decade, and with it has come a new thirst for information. Unfortunately, this book adds little knowledge to fields which have been much better covered elsewhere, both visually and in text.

Presumably this book is intended to fall into the category of books in which the illustrations are of prime importance, with the text in support. Although there are a few good photographs, most of them have little real relevance to the text, many appear to have been enlarged beyond the capacity of the originals (perhaps for dramatic effect), and many of them are of obviously dead specimens; this is not acceptable in these days of refined techniques and with the quality of equipment now available. This book will not find a place on my bookshelf; it is not up to the standard which this generation of readers expects, and is entitled to expect, in its books. — *C. N. Smithers, Curator of Insects, Australian Museum.*

ON TAPE

FROG CALLS OF SOUTH-EASTERN AUSTRALIA: tape and explanatory notes by Gordon Grigg and John Barker. Available from the authors at the Zoology Department, University of Sydney, or from the Australian Museum Bookshop at $4.50 (including postage within Australia).

After every rainy spell, but more especially during spring and summer, the Herpetology Department of the Australian Museum receives numerous distress calls from insomniacal Sydeysiders. They seek a means of stopping the cacophony which has suddenly erupted from ornamental ponds, natural soaks and gutters. The enquirers are often even more distressed by the unsympathetic reception their complaints receive, for the people in the Herpetology Department like frogs. They delight in the many bizarre, and sometimes beautiful, calls made by the 120-plus species of frogs which inhabit this country.

Frogs occur in virtually every major habitat in Australia, and, unlike much of our native fauna, often flourish in an urban enrivonment. It has always seemed strange to me that people who can live unperturbed beside an expressway or railway line, or below the flight path of jet planes, may quickly become neurotic about a frog chorus in their gardens. An understanding of the mechanism of a frog's mating call and its vital rolé in the life-history of these animals cannot fail to arouse one's curiosity at the variety of calls that have evolved.

In the course of excursions through many parts of south-eastern Australia Mr Barker and Dr Grigg have made a splendid series of high-quality recordings of the frog species encountered. The result is a tape which is not only of considerable value to biologists, but one which will fascinate anyone interested in Australia's rich endemic fauna. It will enable those who spend time in the bush to identify many of the frogs whose calls they hear, and it is accompanied by a set of useful explanatory notes.

The tape is rather long (nearly 60 minutes) and only the most enthusiastic would wish to play it all at one sitting. Nevertheless, I can think of few sounds which so quickly evoke the many and varied senses of a warm spring evening in the bushland of south-eastern Australia. — *Harold G. Cogger, Curator of Reptiles and Amphibians, Australian Museum.*

Limnodynastes tasmaniensis

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HOW MANY AUSTRALIANS ......? See page 12.