Australian Natural History

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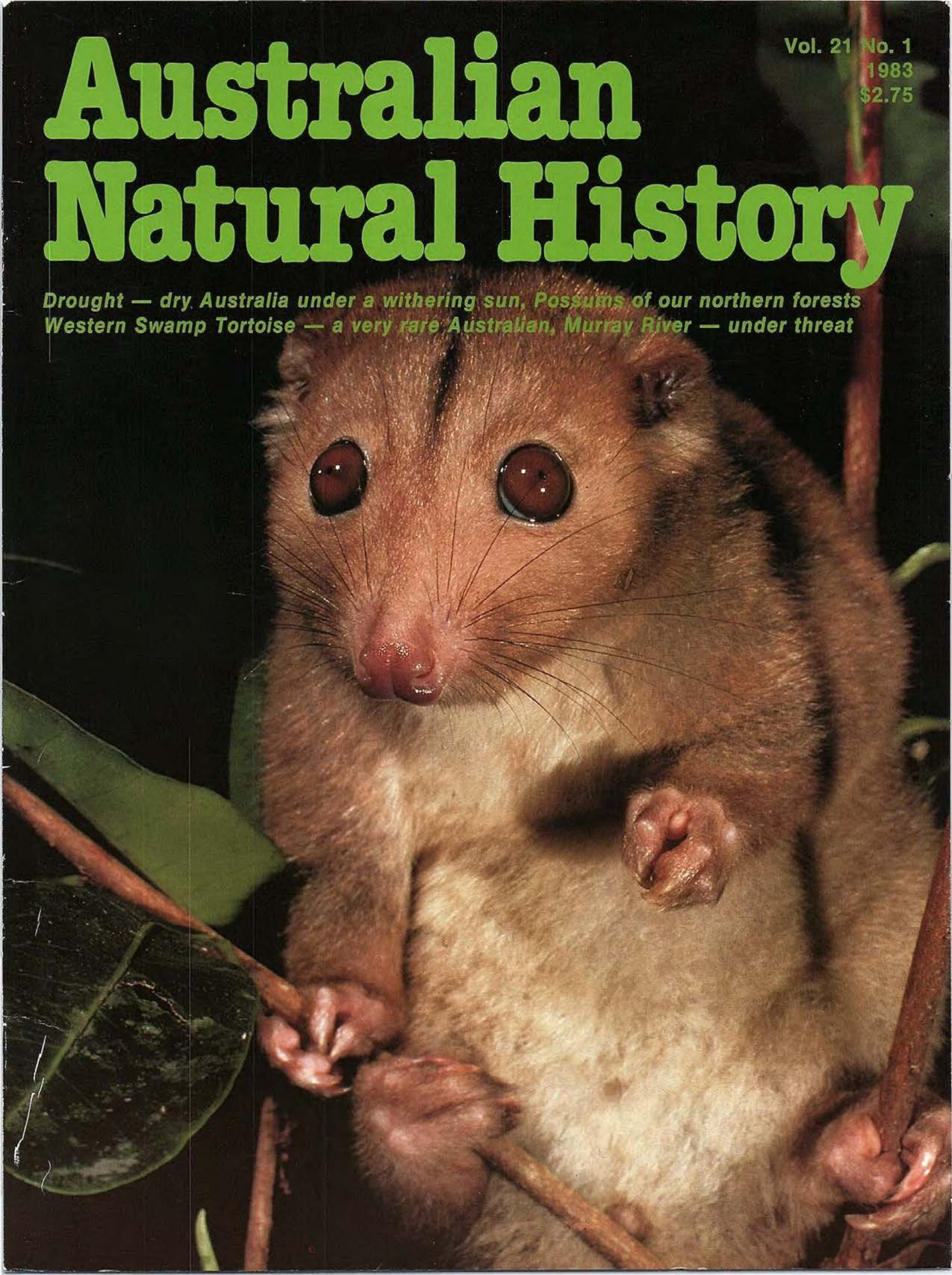
Drought — dry Australia under a withering sun, Possums of our northern forests
Western Swamp Tortoise — a very rare Australian, Murray River — under threat



Australian Natural History

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The Mountain Brushtail Possum, Trichosurus caninus, *as well as inhabiting the forest regions of south-east Queensland, also extends through eastern New South Wales into Victoria. Photo T. & P. Gardner.*

Aboriginal 'dams' were used for a different purpose than their modern counterparts on 'todays' Murray River. This Aboriginal fish trap at Brewarrina was designed to catch some of the immense numbers of fish travellng up the river during early Spring. Photo courtesy of NSW Department of Tourism.

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Cover

A Herbert River Ringtail, Pseudocheirus herbertensis, *is one of our northern possums severely affected by rain forest logging. Photo H. & J. Beste.*

Contents

From the inside

An immense dust cloud full of valuable inland topsoil rolls over Melbourne enveloping the city. Photo Katsuhiro Abe.

As Australian Natural History *enters its 62nd year we would like to take the opportunity to thank all our readers for their keen support and encouragement, particularly after the enormous response to the questionnaire in the Evolution Special of the magazine.*

Over twenty percent of the total number of questionnaires issued were returned and analysed confirming that Australian Natural History *readers are some of the most responsive magazine readers in the country. And indeed, not all our readers live in Australia. Many responses are still arriving from subscribers in other parts of the world.*

By far the most commonly quoted reason for reading the magazine was its immediate and thorough examination of Australia's ecology, conservation and wildlife by the respective experts in each field. An especially pleasing aspect of readers' responses was the number using the magazine for long term personal reference and as a source of material for their studies.

Over the next few issues, as a direct result of readers' suggestions, a number of new features will be included in the magazine. Some are already present in this issue. One immediately apparent change is the magazine's look. This facelift reflects our growth and optimism for the future and will carry Australian Natural History *confidently through the 1980s.*

Roland Hughes
Editor

DROUGHT

by Mary Voice

Rain is the first thing on most Australian's minds as one of the countries most severe droughts moves into its fifth disastrous year in some states. Already with farm produce losses in excess of $2000 million in 1982, five states are facing 1983 with extreme water shortages.

However, loss of produce is not the only effect of the drought. During February, on a day when temperatures soared past 40 deg C, strong, hot northerly winds and a drought-dessicated countryside combined to fuel furious bushfires in Victoria and South Australia. The resulting cost was 72 human lives, property loss and damage of over $300 million and the devastation of large parts of both states. Earlier in the month a dust storm over 500km in length, carrying well over 100,000 tonnes of dust from inland Victoria, swept across Melbourne.

The Bureau of Meteorology, after comparing this drought with seven of the worst droughts southeastern Australia has experienced since 1888, is hopeful that there may be substantial relief this autumn.

Mary Voice is a research meteorologist with the Australian Numerical Meteorology Research Centre (ANMRC), and a member of the Education Committee of the Royal Meteorological Society.

Above and opposite, during 1982 large areas of the east and south of Australia received their lowest winter rainfall on record, while many areas had five-month record lows. The effects on the wildlife and farmer's stock was catastrophic. Photos Kathie Atkinson.

When Captain Cook sailed into Botany Bay in the autumn of 1770, he saw extensive green meadows and running water. Based on his reports, the First Fleet was dispatched 17 years later with spades and hoes but no plough on board, and with an air of confidence that the convicts could live off the land. Such was the lack of understanding of what drought (or even just a dry spell) could do in a country like Australia.

Drought is not exclusively an Australian phenomenon, but it dominates our national heritage more than that of most other countries. Since it is part of the natural spectrum of climate, the occurrence of drought does not mean that the long term weather patterns of a particular region are changing. Sooner or later a period of above average rain will occur.

There are no absolute criteria for drought. The perpetual dryness of the outback was no disaster to nomad Aboriginals and spinifex and kangaroos have adapted happily to extremely arid climates.

Obviously, droughts are anomalies – departures from a rainfall regime to which people, plants and animals are accustomed as the local norm.

The Australian Bureau of Meteorology defines an area as 'drought affected' when the rainfall for a period of three months or more falls within the lowest 10 percent of all previous rainfall totals for the same period of the year. Within the 'drought affected' area, a deficiency is called severe if the rainfall for the period is among the lowest five percent of recorded falls. A drought is considered broken when rainfall for the past month is well above average or for the past three months is above average.

In 1982 large areas of the east and south of Australia received their lowest winter rainfall on record, while many areas had five-month record lows. The length of a dry spell can be important in determining its severity, but the widespread failure of winter and spring rains in 1982, and the resulting devastating crop failures, mean that this drought will rank with the most severe.

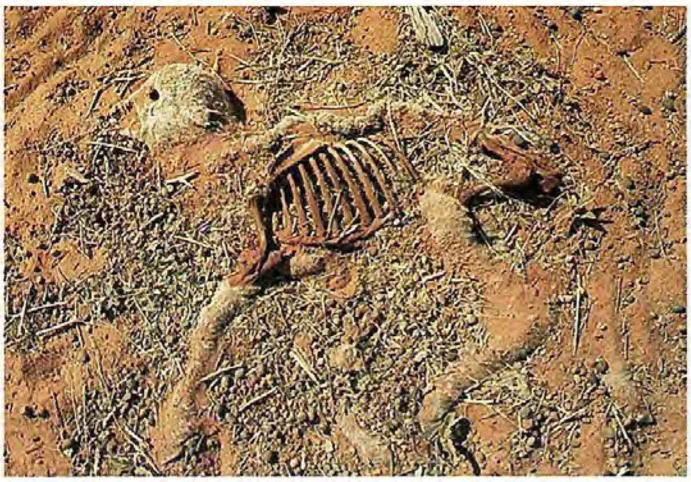
Though the year 1982 saw the lowest recorded falls in many areas of NSW and Victoria, the disastrous deficits in soil moisture in some places were largely due to the cumulative legacy of a preceding run of four dry years.

The history of droughts in this country provides very little evidence that there is any periodicity in their occurrence. Nor do they always have the same duration. However we now know that it would be foolish not to expect one major drought in any 20 year period. A worst possible scenario would see extensive dry conditions lasting in excess of seven years. These estimates can be verified by scanning the list of nine major widespread droughts which Australia has suffered since rainfall records began.

The 1895—1903 drought, one of the worst on record, is known as the Federation Drought. It forcefully marked a new phase in the climate of south-eastern Australia, where there had been many boom years from the 1850's onwards.

The number of sheep in Australia almost halved in one decade, falling from 106 million in 1891 to 54 million in 1902. The 1902 loss in wool revenue was estimated at 2.7 million pounds. Cattle numbers declined by 40 per cent from twelve to seven million, so that most working families ceased to eat good beef.

Dust storms were frequent. In south-eastern Australia the area of ground ploughed for wheat in 1900 was almost six times that ploughed in 1866, and much of that tilled soil, no longer held by moisture or grass, was blown away. On 21 November 1902 so much soil was blown from the interior that Melbourne was coated in dust, and in the afternoon the sun was almost hid-




den by dust-laden air (as occurred in the dust-storm of February 8th, of this year).

The historian Professor G. Blainey suggests that the fluctuations in climate were one of the vital causes of the long prosperity of the forty years to 1890 and of the leaner decades which followed.

It is also worth noting that a fortuitous combination of gold discoveries and favourable agricultural conditions led to Australia having the highest per capita income in the world at the end of the last century.

Optimism even nurtured the idea that Australia, in resources, population and economic power, could be a second United States. The fall of the banks and the unexpected drought in the late 1890s and very early years of this century, ended that idea, marking a step in our slow discovery of the real climate and resources of the nation.

The 1911–16 dry years saw cattle numbers decline by 2 million and sheep by 15 million. In October 1919 the NSW Government made one million pounds available to assist distressed farmers – the 1982 relief package of $320 million begun in October by the Commonwealth Government is probably similar on a per capita basis in real money terms.

Naturally, as our rail and road networks expanded and farming techniques improved, the impact of local or short-lived droughts could be lessened. Nevertheless, in recent times, the 1965–67 drought resulted in a 40 per cent drop in the wheat harvest, a loss of 20 million sheep, and a decrease in farm income of $300–500 million. There was a chain reaction to other industries with heavy losses being suffered by manufacturers of farm machinery, and the railways. Water rationing had to be introduced in irrigation areas.

In the current drought, Victoria's 1982 cereal crop was the worst since 1944, when dislocation due to the Second World War and two years of severe dry conditions caused a very low yield.

LEARNING ABOUT DROUGHTS

What makes Australia a land of droughts and flooding rains? Can we investigate the causes of drought? To answer these questions, we need to take a trip to Melbourne, Victoria where much of the research into Australia's climate is conducted.

At the Bureau of Meteorology Head Office, a 'drought watch' is maintained for the whole of Australia. Regular bulletins are issued to assist government, business and rural communities undertake contingency planning. Meteorologist-in-charge Marcel van Dijk explains that a team effort is required from many divisions of the Bureau. This team has analysed the large scale atmospheric circulation pattern causing the 1982 drought. They contrasted the wet winter of 1981 with the very dry one that followed. The wet winter resulted from mid-latitude cyclones (the low pressure systems commonly seen on our weather maps) moving mainly across Bass Strait, with westerly winds and rain-bearing cold fronts crossing the southern states. By contrast, 1982 pressures were abnormally high over southern Australia, so the cyclone tracks, westerly winds and fronts were generally deflected far to the south.

Are there patterns in the atmosphere which typically produce dry or wet years in certain locations, or are they always different? Meteorologists are now convinced that there are rhymes and reasons to the atmosphere's behaviour which may yield useful long-range predictive tools some time in the future.

At CSIRO's Division of Atmospheric Physics, Dr Barrie Pittock looked for simple patterns and indices which characterise the atmosphere in different seasons or years. He has isolated two indices related to rainfall in eastern Australia. One of these is the monthly average of the latitude of the

Scenes from the drought now occurring in south-eastern Australia. This drought now rivals the notorious 1965-67 drought which caused a 40 percent drop in the wheat harvest, a loss of 20 million sheep, and a decrease in farm income of $300-500 million. Photos top left and bottom right, Kathie Atkinson, others courtesy of the NSW Department of Agriculture.

high pressure belt near the east coast of Australia. When this belt moves further south, the rainfall is above average on the eastern coastal margin, while rainfall tends to be below average when the pressure ridge moves further north. Conversely, the southern coast has decreased rainfall when the high-pressure belt moves south and increased rain when it moves north.

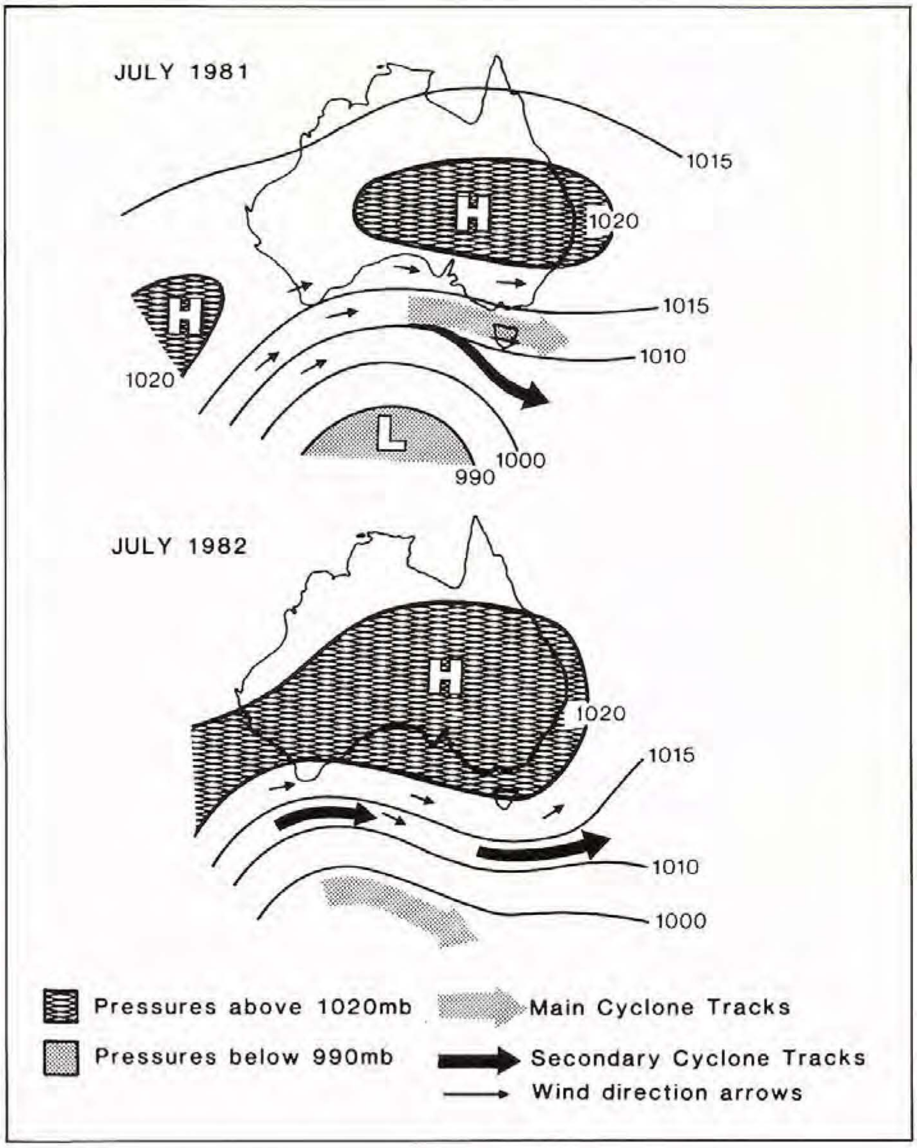
Schematic pictures of the rainbearing winds explain why this index generally correlates well with rainfall over the southeastern coastal areas of Australia.

The pattern of the dry winter of 1982 only partly fits this hypothesis. The high pressure cell was further south than normal but it also expanded in area and increased in strength. As a result, the south coast received very low rainfall, but there was no corresponding increase on the east coast.

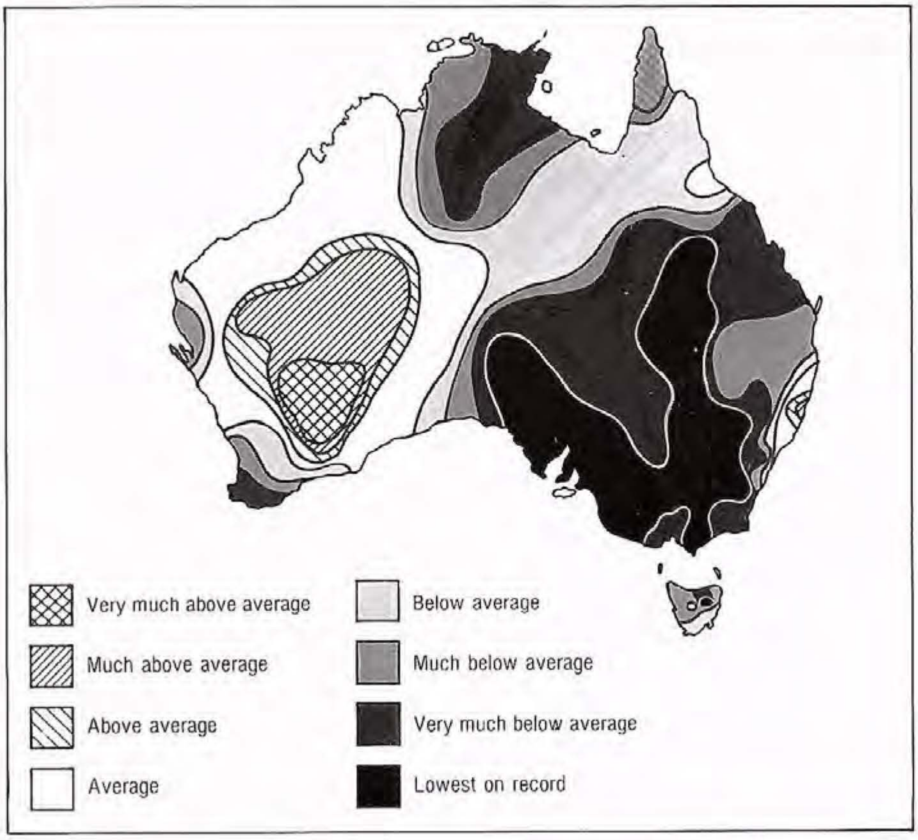
The second index (the so-called Southern Oscillation Index (SOI)) which Dr Pittock studied depends upon the large scale features of the ocean and atmosphere in the equatorial Pacific. The Pacific is such a huge ocean that equatorial currents and sea temperatures have a very important effect on the whole of the Southern Hemisphere's weather regimes. When barometric pressures are low in tropical Australia and high in the central Pacific to the east (one extreme of the SOI), rainfall is high over much of northern and eastern Australia. When pressures are reversed across the Pacific, there is decreased rainfall in the same areas of Australia. A logical, physical explanation for these relationships will be given shortly.

We have seen already that 1982 winter was near the dry extreme of the index applying to the south coast strip. It was also a very good example of the dry extreme of the SOI, which affects almost half the continent (north and east).

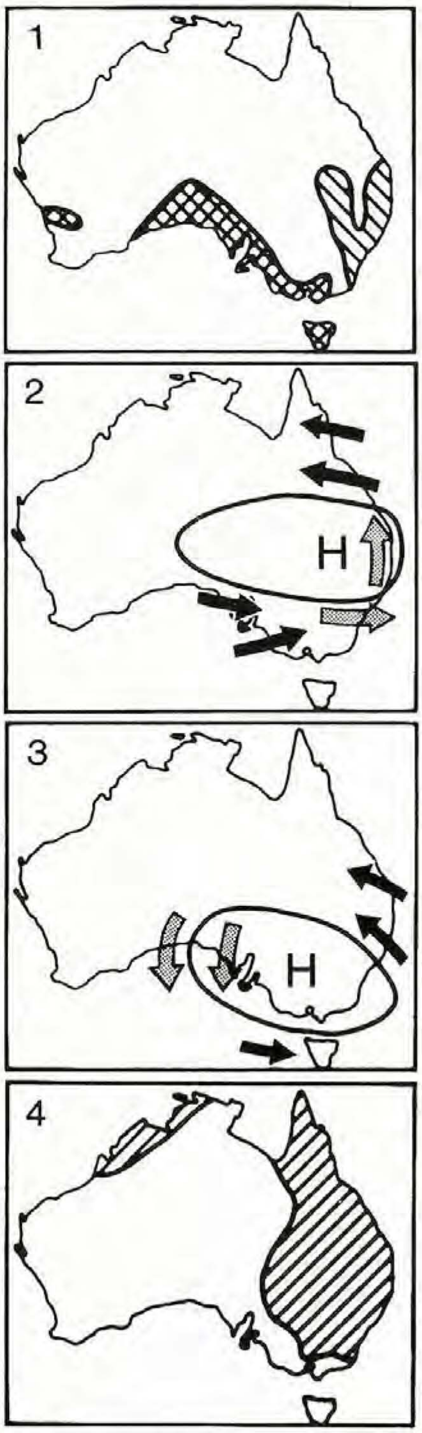
An old saying warns us that there are lies, damned lies, and last of all statistics. Clearly, the warning is meant to remind us of the improper use which can be made of statistics. Neville Nicholls of the ANMRC takes this caution to heart and treats his work with the utmost care and precision. For he is applying statistical techniques, such as



The diagram above contrasts the behaviour of the atmosphere between two very different years. While 1981 had good rains in the southern states, 1982 was extremely dry. Monthly average surface pressure maps show how much higher the pressures were over the continent in 1982. As a result, rain bearing westerly winds were diverted southwards and tracks of cyclones (low pressure systems) mostly missed the continent.



Right, the distribution of rainfall for the six month period, July to December, 1982. Note the large area of sheep and wheat country which received the lowest ever July to December rainfall.



1. The see-saw effect of rainfall between the east coast and south coast of Australia. The rainfall is simultaneously high in one area and low in the other, depending on whether the high pressure systems (anticyclones) are further north or further south than normal. The shaded areas show where the first study was made by the Australian Numerical Meteorology Research Centre meteorologists.
2. Schematic winter flow patterns when highs (anticyclones) are further north than normal. Rain is high on the south coast, low on the east coast. Moisture bearing winds are black, dry winds (blowing off the continent) are grey.
3. Schematic winter flow patterns when the average position of the high pressure systems are further south than normal. Rain is low on the south coast, high on the east coast.
4. The area where the second study was conducted.

the so-called lag correlation, to test relationships between atmospheric pressure in the far north of Australia and rainfall in the wheatbelts of the south. He has confirmed that if the pressure is above average around Darwin then there is a definite tendency for the rainfall in southeastern Australia to be low one, two or even three months later. He also knows that the relationship is stronger in some seasons than in others and that it fades out during late summer to autumn.

How can such information be conveyed to farming and industry in a way that cannot be misunderstood or misinterpreted, or distorted when passed on by word of mouth? Mr Nicholls believes that education is the best way to familiarise people with the use of probability estimates. In the meantime, he remains cautiously confident that his work will prove useful to farmers in the future.

The link between Mr Nicholl's work and that of another ANMRC scientist Dr Neil Streten, is the temperature of the sea surface. Air masses lying over warm sea waters will tend to pick up some of the sea's warmth. Generally speaking, warm air is light and expands relative to neighbouring cooler air. The end result is that warmer air will have a lower pressure than the cooler parts of the atmosphere nearby.

Remembering that Mr Nicholls used atmospheric pressure at and around Darwin in his study, we can appreciate the link to sea surface temperatures. When sea temperatures are colder than normal in the Timor and Arafura Seas, pressures generally will be high over northern Australia near Darwin (and so a connection to lower rainfall in the wheatbelts of Victoria and New South Wales follows). Conversely, warmer than normal sea temperatures lead to lower pressures and higher rainfall than average.

Remember also, that the second index (the SOI) studied by Dr Pittock was linked to the tropical sea temperatures around Australia via the atmospheric pressures.

However, Dr Streten's work extends further. He has shown that a sufficiently large area of cold water somewhere close to the Australian coast is likely to produce reduced rainfall over some part of Australia. Unfortunately, it is impossible at this stage to predict the precise areas where rain will be lower or by how much.

Meteorologists do have a general understanding of why the rainfall is altered. Warm oceans are a major heat (energy) source for the atmosphere. When the sea temperature is warmer, more water evaporates into the atmosphere to be deposited as rainfall elsewhere. At the same time, atmospheric circulation patterns change. On average, lower pressures occur over the warmer waters. Storm tracks and average positions of high pressure cells alter subtly. Average wind directions shift, bringing moister air to some locations, drier air to others.

The winter of 1982 is an excellent example of the difficulty of issuing precise seasonal rainfall forecasts. We have seen how the atmospheric patterns did indeed conform to the theories on drought of many scientists. Nevertheless, the myriads of variations which the atmosphere can adopt, deny us the ability to give detailed quantitative predictions of the rainfall deficits, or to specify accurately the areas which will be dry.

The sea temperature anomalies for winter of 1982 reinforce this conclusion. The schematic inferences drawn from the anomaly patterns agree beautifully with the scientific theories, including those of Dr Streten. Ocean surface temperatures generally were cold around the Australian continent for a period of four months or more, during the height of the rainfall deficiencies. The well-above-normal temperatures in the central and east Pacific weakened the trade winds approaching our northeast coast, denying much needed rain in inland Queensland.

On the other hand, the appearance of the anomaly pattern is patchy and complicated in some areas. It would be very difficult to draw more detailed inferences about how the atmosphere should respond to such a pattern in the ocean, than we have done already.

Slowly then, atmospheric researchers are building a coherent picture of

AUSTRALIA'S MAJOR DROUGHTS

1864-66 All states were affected except Tasmania.
1880-86 Southern and eastern mainland states were affected.
1888 All states were hit except Western Australia.
1895-1903 A long-lived drought over large areas of Australia.
1911-1916 Particularly affected the southern states.
1918-1920 During this period parts of Western Australia were the only areas completely free from drought.
1939-1945 This prolonged drought affected crops and/or pastoral areas in all states.
1965-67 This drought, in its impact on Queensland, New South Wales and Victoria, ranked with the 1902 drought as one of the most severe on record.
1972 Widespread drought throughout Australia.

the modes of operation of the atmosphere in the Southern Hemisphere. One final component in the researchers' repertoire is the computer model. Barrie Hunt and Mary Voice, again at ANMRC, are using this valuable research tool for climate studies.

The atmosphere is a fluid which responds to the forces acting on it. Among these are the forces resulting from the spinning of the earth on its axis and the heating and cooling by radiation, convection and moist processes occurring in the atmosphere.

These forces and the resulting patterns of air flow can be described by mathematical equations. While these equations are too complicated to solve exactly, they can be solved to a very good approximation by a computer.

The computer model can be used to simulate the behaviour of the atmosphere throughout a number of days, weeks or months. While this simulation will not correspond exactly to how the real atmospheric patterns would have developed, the picture will be close enough to allow general conclusions to be drawn and some hypotheses tested.

For example, the simulated monthly average pressure patterns from the computer are realistic and meaningful to the climatologist.

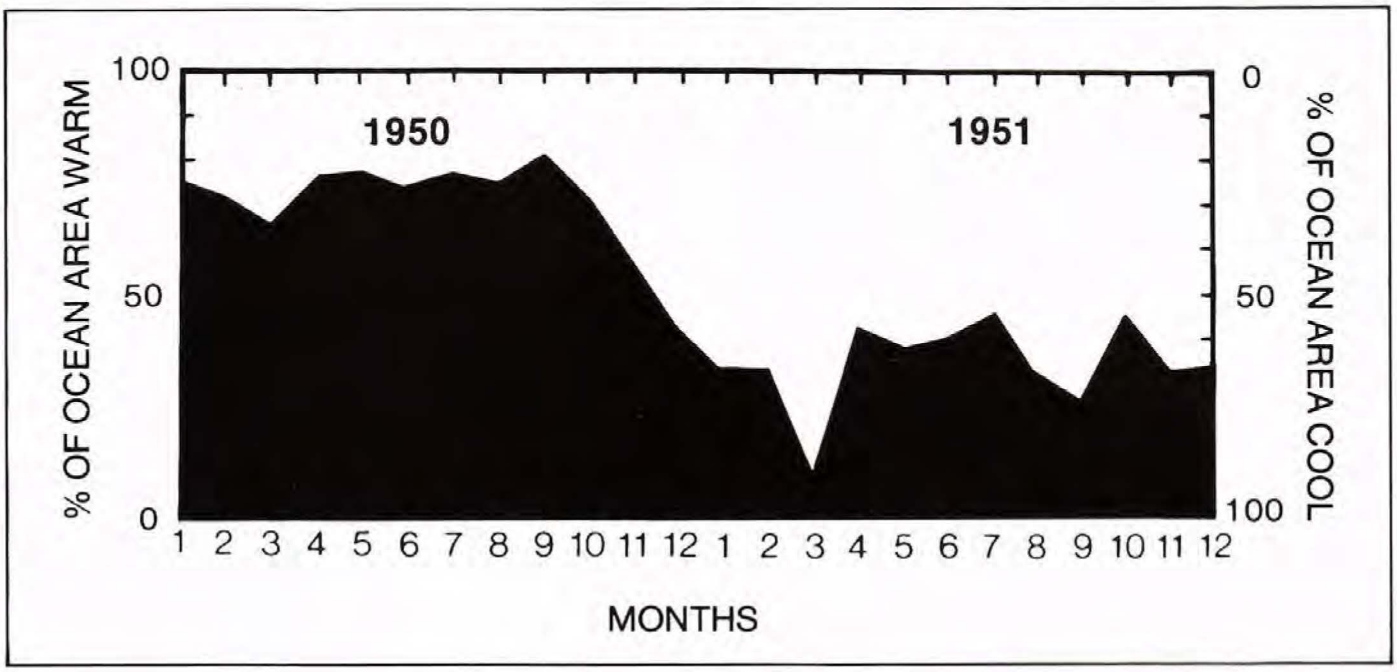
The theories which propose that sea temperatures influence climate, can be tested using the computer models. One computer simulation with normal sea temperatures can be compared with another where the sea temperatures are different. The changes in the simulated flow patterns between the two cases are checked against the arguments and observational evidence of the scientists. Broadly speaking, the tests with computer models reinforce the validity of some hypotheses previously discussed.

A clear message comes through from all of the studies, namely, that a broad understanding is emerging of the mechanisms and atmospheric patterns associated with major droughts. At the same time, the minutiae of detail for an individual drought, for a specific location or for a particular week or month, are beyond the scope of current understanding.

We now know that drought is associated with identifiable large-scale pressure and wind patterns in the atmosphere. These patterns are clearly distinguishable from those occurring in a 'normal' or a 'wet' year, and often extend across the whole Southern Hemisphere.

Top, on February 8th, 1983 Melbourne was hit by a massive duststorm which was a direct result of the drought. Photo Katsuhiro Abe.

Middle & below right, the difference between a drought crop and a good crop in the north-west of Victoria.



The ocean is an important factor in the drought story because it is a heat source for the atmosphere which varies depending on the sea surface temperature. A potential exists for medium-term forecasting using the ocean state because sea temperature anomalies tend to persist for one, two or more months. This persistence of ocean anomalies results in a certain probability that atmospheric anomalies will be established and also persist. As a result probability predictions of rainfall amounts for some places and some seasons are becoming possible.

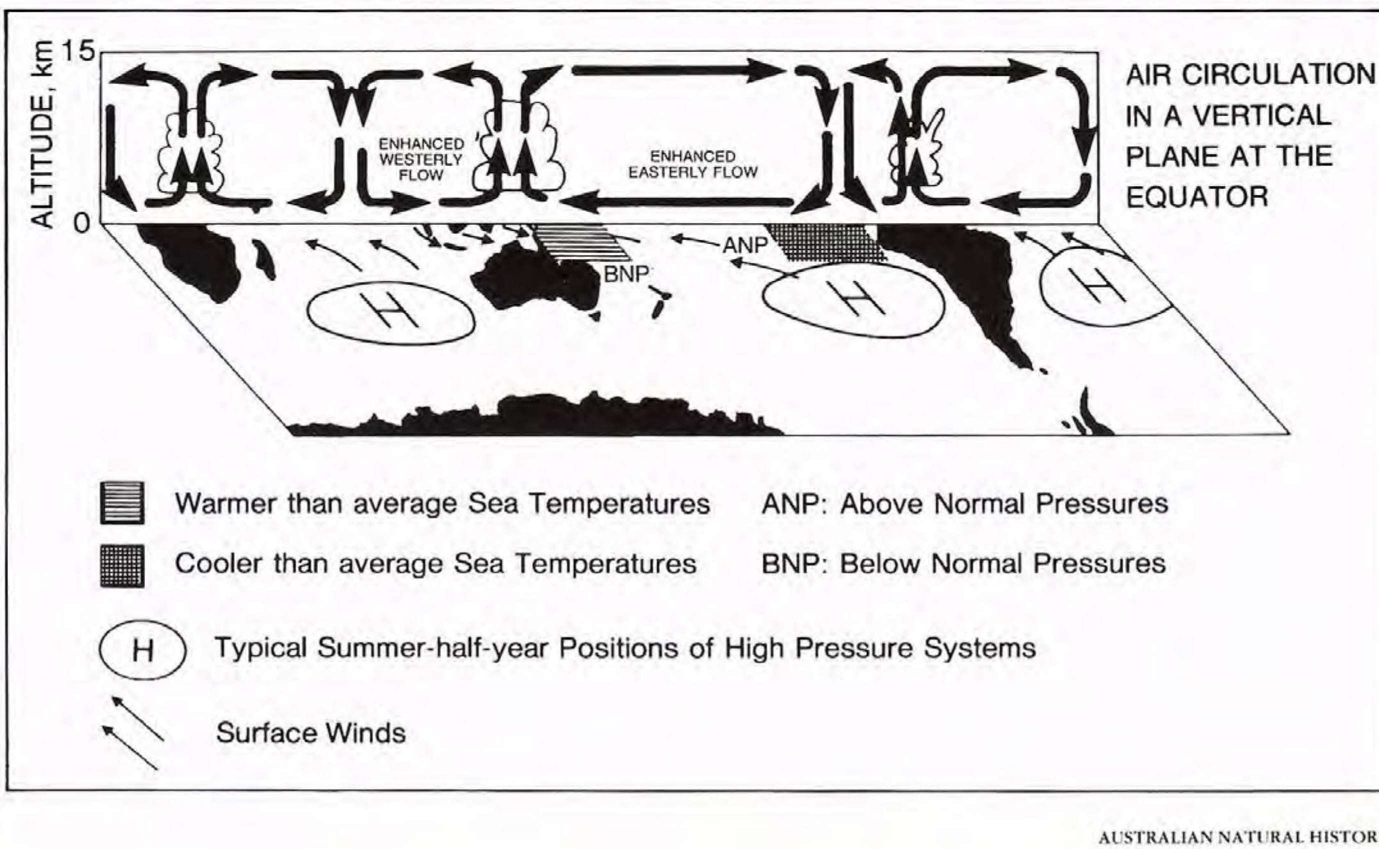
Informative and promising as the research efforts just described are, a drought can never be prevented. We all know that irrigation can be used to ameliorate the effects of rainfall deficiencies in marginal regions. But what are the water requirements during a drought covering an entire district, or the whole of NSW or Victoria?

Assume most crops need about two centimetres of rain per month. Just to supply one square kilometre of land with one month's water, we would need 20 million litres of water. This would require 500 petrol tankers per month (or over 15 per day), full of water, travelling from some water-rich region, say the coast.

Suppose cattle and sheep only need one quarter that of crops (some for drinking, some to maintain a minimum

Percentage of ocean area surrounding Australia (black area) with above-normal sea temperatures during the two year period 1950-51. Roughly 70 percent of Australian waters were warm in 1950, dropping dramatically to only about 30-40 percent in 1951. 1950 was a wet year on the continent, 1951 a dry year. These two years show that sea temperatures over large areas can stay consistently high or low for months on end; but that a change from warm ocean (wet land) to cool ocean (dry land) can occur within the space of six months.

Below, Southern Hemisphere conditions prevailing in a typical wet summer half-year in Australia.



of fodder). Then a rough estimate for a drought area the size of Victoria alone could be in excess of 50 million tankers full of water needed per month!

Obviously then, a stop-gap measure such as carting water is out of the question. It is beyond the capacity of our transport system, and would be hopelessly uneconomical.

Normally, the atmosphere is able to provide this water. A very ordinary low pressure storm (or an active cold front) drops well over 100,000 million litres of water in just a few days (over three million tankers full). These amounts are staggering when you consider that this water is 'hidden' in the air in the form of vapour before the clouds form and precipitation begins.

We must always remember that drought poses special problems for the farming community because it creeps up gradually on the afflicted area. Deciding when and how much to sell or keep is then a difficult problem. Surveys have shown that farmers in the past underestimated the likelihood of the rare climatic event. Even today, young farmers quite often enthusiastically say that "with modern agricultural techniques, it can't get as bad as it was in the past."

SOUTHERN OSCILLATION INDEX

An index of an atmospheric circulation type occurring in the Southern hemisphere is known by meteorologists as the Southern Oscillation Index (SOI). This index compares pressures in tropical Australia with those in the central tropical Pacific. The extreme produces above normal rain over much of Australia.

In the tropics, winds tend to blow from high to low pressures, so this pattern produces enhanced flow of humid tropical air onto the Australian continent from the north and east. As well, converging air near the ground rises and produces cloud and rain.

During the opposite extreme of the SOI, pressures are relatively high over northern Australia, the air circulation shown in the vertical plane tends to die out or reverse. Trade winds are considerably weaker over much of the Pacific. With little or no flow of moist winds across the continent and no updraughts to produce clouds,. drought is well and truly on the cards.

The flow patterns of 1982 are in this latter category of the SOI.

A dried-up creek bed resulting from the continued effects of the drought. Photo A. L. Farr, Soil Conservation Service of N.S.W.

As was seen earlier, droughts in Australia can last anything from a few months to longer than five years. A practice which seems obviously inconsistent with the conditions of arid-region farming is the annual accounting period. While some special cost-spreading arrangements are available now to farmers, a five to ten year accounting period would seem more in tune with cycles and durations of droughts, and might enable improved land husbandry. However, socio-economic institutions are notoriously difficult to change.

Irrespective of improved economic and agricultural skills, the vulnerability of the land to drought has decreased only marginally. As one example, Mallee farmers in the far northwest of Victoria have learnt new ploughing techniques to create mini-dunes across the wind direction. The wind then transports soils from one dune to the next and less of it blows away altogether.

Valuable though this method of ploughing is, it is by no means perfect in very dry years. Over most of Australia, it should be stressed, loose sandy soils are still exposed to wind erosion during drought. The floods which often follow can then be equally as damaging to the unstable unprotected topsoil.

The summer of 1982/83 provided dramatic confirmation of these dangers. Melbourne was hit by a massive dust-storm on Tuesday February 8, 1983, an event not experienced since 1902. No doubt, the tragedy of the 1939 Black Friday bushfires in Victoria will be supplanted in people's memories by the disastrous fires of Ash Wednesday, February 16, 1983 throughout Victoria and South Australia. In South Australia, two weeks after these fires swept through the hills leaving no protection for the soil, heavy rains created rivers of mud which effectively doubled the damage.

Meteorologists and climatologists agree that protection of farming lands is the area where long range forecasting ultimately may be of most benefit to the nation. More immediate benefits can be seen by the Australian Wheat Board. It has been estimated that a 10 percent improvement in predicting wheat production could be worth $7 million annually to NSW alone, and the seasonal weather conditions are a significant component of agricultural productivity forecasts.

A decade or two from now, the skills of the atmospheric scientist may be such that, when combined with agricultural, economic and farming expertise, the nastiest aspects of drought may be ameliorated. As a drought prone country, we must work for that goal. We remain ignorant of climate at our peril.

FORUM

This is the first of what will be a new feature in Australian Natural History, namely a chance for well-known Australian scientists to air their views. Michael Archer, is a specialist in mammal evolution, a Museum Research Associate and Senior Lecturer in Zoology at the University of New South Wales.

'Scientific Creationism'—An unnatural history of gobbledegook

Among the morally disillusioned and often intellectually bankrupt, 'Scientific Creationism', like the Unification Church (Moonieism), Scientology and other fringe religions, is becoming fashionable. 'Creation Science' is based on the idea that scientific analysis will reveal that every statement made in Genesis is literally correct. With its acceptance comes rejection of the methods and findings of real science and, in no uncertain terms, a formidable force pushing us back towards the Dark Ages.

Modern philosophers, studying similar phenomena through history, have noted that these episodes of return to Biblical fundamentalism correlate well with periods of stress in society, such as after wars, depressions and so on. Today's upsurge in fringe religions is in this context entirely understandable. We are in a recession, jobs are scarce and people are desparate. This is the ideal breeding ground for fundamentalist religions. They offer and can give spiritual comfort to the growing numbers that need it. To give this comfort, they will perform a religious frontal lobotomy. Once it's done, doubts and worries disappear and the patient smiles a lot.

So who am I to bother about this resurgence of Biblical fundamentalism and the growing number of mindless but smiling people? Why should I use up precious space in Australian Natural History to talk about what should be a private matter for every individual to decide: operation or no operation?

The answers are simple. First, I am one of the group of scientists whose results are being lied about by the 'Scientific Creationists'. If I sit by and let their lies, misrepresentations, misquotations and verbal slights of hand put out the intellectual lights of a fellow human, I will have failed in my responsibilities as a scientist.

Second, if the cancer of 'Scientific Creationism' continues to infiltrate our Australian educational system at its present rate, it is not just individuals who will suffer. It will soon begin to effect what we are allowed to teach in schools.

In this, and future columns, I intend to examine the Creationists' claims about 'evidence' from the natural world that according to them supports the literal truth of Genesis.

Let's start with their statement that the tracks of dinosaurs and humans have been fossilised together. This situation would be seen as support for the Genesis account which states that before the Biblical Deluge, all created kinds of animals coexisted. Therefore, dinosaurs and humans could have traversed the same bit of gooey mud on the same day. Subsequently, because of The Flood, the poor but wicked dinosaurs perished while humans sailed off into the future on the Ark. According to evolutionists, the last dinosaur died out about 63 million years before the first human evolved, so they could not possibly have slapped their feet into the same bit of gooey mud on the same day.

The Creationists claim that fossilised tracks of humans occur with those of dinosaurs in the Cretaceous Glen Rose limestone along the Paluxy River in Texas. On the face of it, the claim is intriguing. If correct, it would be tangible proof of coexistance. But is it correct? The dinosaur tracks are clearly distinctive and represent known forms. However, the 'human' tracks are evidently enormous (one is 53cm long). But then it says in Genesis that there were giants in the earth in those days so perhaps size is no problem. However, some of the 'giant man' tracks have a rear claw print and others have the instep on the outside rather than the inside of the track. These abberations are rather difficult to accept as attributes of human feet but not at all problematical as features of poorly preserved dinosaur tracks or scour marks made by half-submerged logs.

Most revealing are a series of photographs of a Paluxy River 'giant man' track taken by a Creationist and claimed to depict the 'best single track'. Clearly these were taken at different times as well as from different positions. The first shows a shiny well-demarcated large human-like track with five toes, including a big first toe, 20cm away from a very distinctive dinosaur track. This certainly looks impressive. Then we read the legend of the figure: "These tracks (*Trachodon* and giant man tracks) are eight inches apart and were wet out with vaseline and alcohol for photographic purposes". So a doubt creeps into my mind. Has the photographer, perhaps guided by a good imagination and a wishful eye, demarcated with vaseline more or less than is really there? The answer is easy to determine. In fact, he has done both.

The photographs show that an early attempt was made using a sand bag to keep a puddle of water from extending into the 'giant man' tracks, ostensibly because it would obscure the track. That worry was well-founded. The third photograph must have been taken just after rain. The sand bag had failed and the whole area was wet. Suddenly, without the 'clarification' of the vaseline, there are no toes distinguishable and, curiously, there is another whole section to the depression of which the vaselined portion was only half. The shape of the whole depression is decidedly non-human-like. It may be a scour mark, or a poorly-preserved dinosaur track. It is not the track of a human, giant or otherwise.

It is apparent that this "best single giant man track" is not acceptable evidence for believing that humans and dinosaurs coexisted, but it is evidence of chicanery. 'Creation Scientists', determined to have scientific evidence to refute the claims of evolutionists, commonly cite these Paluxy River tracks as striking evidence for the nonsense of evolution and the literal sense of Genesis.

This example of the sort of evidence accepted by 'Creation Scientists' is entirely typical. After reviewing the Creationists' 'case' against evolution, Michael Ruse, an historian and philosopher of biology, concluded: "The Creationists are at the bottom of the scale. They pull every trick in the book to justify their position. Indeed, at times, they verge right over into the downright dishonest. Scientific Creationism is not just wrong: it is ludicrously implausible. It is a grotesque parody of human thought, and a downright misuse of human intelligence. In short, to the Believer, it is an insult to God" (*Darwinism defended,* 1982, Addison-Wesley: London).
Amen brother.

Michael Archer.

"Come from nowhere... then just disappear"

by Jeanette Covacevich & Charles Tanner

Southwest Queensland is an area of extremes where millions of rats and snakes with one of the most toxic venoms known, have lives which appear closely linked. Both Jeanette Covacevich, Curator of Reptiles at the Queensland Museum and Charles Tanner, a herpetologist with a long association with the National Museum of Victoria, were involved in the rediscovery of the large, dangerous Small-scaled Snake or Western Taipan, *Oxyuranus microlepidotus*, in the early 1970s. At present, after studying native species of rats and mice, they are working on the association between the Long-haired Rat, *Rattus villosissimus*, and the Small-scaled Snake.

The Channel Country of southwestern Queensland is one of the harshest environments in Australia. Summer temperatures in the mid 40s and winter temperatures below freezing are 'normal'. Annual rainfall is sparse (less than 100mm on average) and extremely unreliable, leaving the country to the mercy of prolonged droughts. These are often followed by severe floods.

The plants and animals which have evolved under such extremes cope through a combination of behavioural, physiological and morphological adaptations. The Long-haired Rat, *Rattus villosissimus*, and the Small-scaled Snake or Western Taipan, *Oxyuranus microlepidotus* are well adapted to the vast, arid, ashy downs of the Channel Country and their lives appear to be closely linked.

The most interesting feature of the Long-haired Rat is the fact that its populations literally 'explode' and plummet regularly, but infrequently. Such 'plagues' usually occur following floods when green feed is available, and usually happen suddenly.

In non-plague times the Long-haired Rat is reasonably rare. However, small highly localised colonies occur in the Lake Eyre Basin and in moist refuges on the Barkly Tableland.

Plagues of the Long-haired Rat seem to spring from increases in many local populations leading to a mass migration of the animals to escape an often harsh and lethal environment. The trigger for these plagues is not understood, but it is generally agreed that a good season preceded by rain, and often a flood, is a major factor.

The Long-haired Rat, Rattus villosissimus, *is adapted to survive the rigours of life in the Channel Country through massive population explosions in response to favourable conditions. It must have moisture and green feed unlike some of the other mammals in the area which thrive without water on seeds or insects.*

Also important is the Long-haired Rat's extremely high breeding potential. In ideal conditions the female can breed at the early age of 62 days and produce litters of up to 12 young. Couple this with a breeding season of 12 months and a gestation period of 21—23 days (mating may occur straight after the female has given birth) and it is not surprising that the rat populations literally 'explode'.

The earliest known record of a rat plague, was in 1847. During 1973—74 one of the largest plagues known occurred in southwestern Queensland.

Another plague of uncertain proportions is now in progress in the Birdsville-Betoota area. On Durrie Station, near Birdsville, heavy rain (approximately 250mm) fell in the first three months of 1981 and resulted in a flood of the Diamantina and its channels. In May of that year there was a further fall of 100mm. Naturally, in

Above left, ashy downs of the Diamantina River channel systems with remnants of fast-growing Channel Millet, a major food source for Long-haired Rat populations.

Long-haired Rats emerge from their burrows to feed as soon as night begins to fall.

response to so much moisture, vegetation flourished. Channel Millet, *Echinonchloa turnerana,* a fast-growing, prolific seed plant, sprang to life along with a host of other potential food sources for the rats.

Jim Evans, the manager of Durrie, noticed the appearance of the rats in November, 1981 after a spectacular build up in their numbers. Members of a Queensland Museum team sent there to collect rats were struck by their sheer weight of numbers. Rats were everywhere and at night they were literally carpeting the paddocks and grasslands.

Experiences such as this help substantiate other reports of spectacular plagues made in the past. A report from another Channel Country homestead of the killing of 100,000 rats during the 1940 plague is now not hard to believe.

Rat numbers decline dramatically with shortages of food and water, reduced reproductive capacity, and predators. Cats, dingoes, foxes, birds of prey, goannas and snakes feast on the rats. A major predator in some areas is the Small-scaled Snake or Western Taipan, *Oxyuranus microlepidotus.* Closely related to its better known cousin the Taipan, *Oxyuranus scutellatus,* the Small-scaled Snake was described in 1879. It was known only from two specimens collected at the time and not seen again until the early 1970's. We now know the Small-scaled Snake only occurs in the ashy downs of the Diamantina River and Cooper's Creek drainage basins, in the Channel Country.

The Small-scaled Snake has the most toxic venom of all terrestrial snakes. A maximum yield of Small-scaled Snake venom (110mg) is sufficient to kill more than 250,000 mice.

With black heads, brown bodies some snakes are known to possess faint body banding near the tail. The Small-scaled Snake grows to a length of 2.5 metres and lays between nine and twelve eggs. These take about 66 days to hatch.

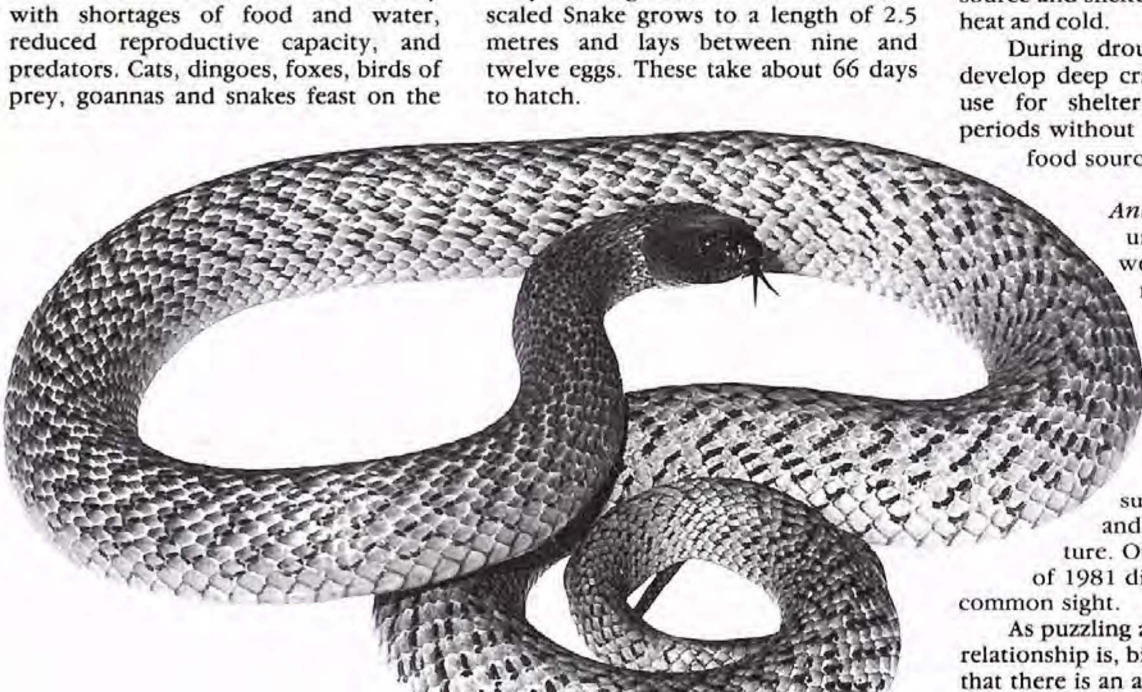
Studies show that the snake is rarely seen except during and immediately after rat plagues. Snakes caught in the Channel Country during September 1974, at the tail end of a massive rat plague were all in peak condition.

Regardless of rat numbers Small-scaled Snakes spend most of their lives underground in the network of rat burrows. This habit has a two-fold advantage for the snakes — a ready food source and shelter from the extremes of heat and cold.

During droughts the ashy downs develop deep cracks which the snakes use for shelter, surviving for long periods without food and water. Other food sources during rat shortages include the Kultarr, *Antechinomys laniger,* an uncommon marsupial as well as other small mammals and ground birds.

Despite annual visits by Queensland Museum scientists very few Small-scaled Snakes have been seen. Two captured in 1976 were suffering from starvation and died shortly after capture. Only with the rat plague of 1981 did they again become a common sight.

As puzzling and coincidental as this relationship is, biologists can only guess that there is an association between the Long-haired Rat and the Small-scaled Snake. Accurate surveys have not been undertaken to prove that the snake populations rise and fall with those of the rat. The snakes may just be more



A large Small-scaled Snake.

A Long-haired Rat (photo H. & J. Beste, NPIAW) and below, a particularly well-fed Small-scaled Snake near Windorah in 1975 towards the end of a rat plague.

conspicuous when food is plentiful.

Jim Evans, the manager of Durrie Station in the heart of the country most favoured by both the Long-haired Rat and the Small-scaled Snake, understands the place and its animals. He has known several plagues of both rats and snakes and sums up the whole process "... they seem to come from nowhere, overrun the place, and then just disappear".

That is certainly the impression they give — nothing, then countless thousands of rats, many daily sightings of snakes and again, quite suddenly, few or none of either for another seven to ten years.

The Western Swamp Tortoise is a member of the reptile family Chelidae — primitive side-necked fresh water tortoises or turtles which occur only in Australia, New Guinea and South America. The taxonomy of Australian side-necks is currently under study and several species remain to be described and named. There are five genera. Three of these, Chelodina, Emydura *and* Elseya, *each have a number of species, most of which are fairly common and have widespread distributions. The two remaining genera,* Rheodytes *(which is found in the Fitzroy River, Queensland) and Pseudemydura, each have only one species and they are extremely rare. All Australian tortoises belong to the Chelidae except the soft-shelled* Carettochelys insculpta, *a recent migrant to Northern Australia from New Guinea.*

A very

by Andrew Burbidge

One of the world's rarest animals, the Western Swamp Tortoise, *Pseudemydura umbrina,* only has a total population of some 45 to 50 individuals of which 22 live in the salubrious confines of Perth Zoo. The remainder occupy two nature reserves on the edge of the Swan Valley, near Perth. While there is no single, simple reason for the extreme rarity of this highly specialised animal, biologists are concentrating on captive breeding as a means of enabling the tortoise populations to recover.

Andrew Burbidge, Chief Research Officer at the Western Australian Wildlife Research Centre, a branch of the WA Department of Fisheries and Wildlife, has studied the Western Swamp Tortoise since 1963. In this article he describes the life history of this remarkable animal outlining the reasons for its rarity and the problems of preventing its extinction.

The first specimen of the Western Swamp Tortoise was obtained by the German collector J.A.L. Preiss in 1839, and lodged in the Natural History Museum, Vienna. Its label, 'New Holland' gave little clue as to its habitat or whereabouts. Nothing more was heard of it until 1953 when a boy brought a live specimen to the WA Naturalists' Club's annual wildlife show. He found it walking across a road near Warbrook, within the Perth Metropolitan Region, only 30 kilometres north-east of the city centre.

The rediscovery generated a lot of public interest and it soon became apparent that conservation measures were needed. Dubbed by Western Australians the 'Short-necked Tortoise', to distinguish it from the only other local species, the Long-necked Oblong Tortoise, *Chelodina oblonga,* the Western Swamp Tortoise became the focus of the nature conservation movement in Western Australia until another extremely rare species, the Noisy Scrub-bird, was rediscovered in 1961.

Early surveys revealed that the tortoise only occurred in a very small region on the edge of the Swan Valley, in the Upper Swan/Warbrook area. Few

Above, a six month old Western Swamp Tortoise. The marked 'ring' on each scute shows its size at hatching.

Left, part-filled swamp in Twin Swamps Nature Reserve with Melaleuca raphiophylla. *All photos in the article by A. G. Wells.*

rare Australian
the Western Swamp Tortoise

areas of natural bush remained and very little was Crown land. Long negotiations, augmented by funds donated by the public, culminated in 1962 with the declaration by the Western Australian Government of two nature reserves including almost all of the tortoises' known habitat.

Significantly these were the first reserves set aside in Australia specifically for the protection of a reptile. The Twin Swamps and Ellen Brook Nature Reserves, of 155 and 65 hectares respectively, were proclaimed Class A under the Western Australian Land Act and cannot be alienated nor put to another use except by Act of Parliament. Both reserves are vested in the Western Australian Wildlife Authority.

Although only five kilometres apart the two nature reserves embrace quite different types of country. The forty percent of Ellen Brook Nature Reserve inhabited by the Swamp Tortoise contains undulating clay soil. The depressions fill rapidly with water after the first heavy winter rains while the high ground, remaining dry, is covered with a dense heath. The soil of the higher areas contains natural 'gilgai' tunnels.

Twin Swamps Nature Reserve is sandy. The swamps occur in depressions with a hard pan below the surface and need a lot of heavy flooding rain before they fill. The low sand dunes surrounding the swamps are covered with *Banksia* woodland typical of much of the coastal plain near Perth.

Immediately following the declaration of the nature reserves, studies began in order to devise an effective management plan. Studying any rare animal has its problems. During the first three years only five, 14 and 11 tortoises respectively, were captured and most of the information was gained by radio-tracking. Custom built transmitters were designed for each tortoise and glued to the carapace with polyurethane foam to neutralise buoyancy. The transmitters had a range of 200m, worked underwater as well as in air, and had a life of six months. The natural history of the tortoise turned out to be most unusual.

The Western Swamp Tortoise is the smallest Australian tortoise. Males, which reach a carapace length of 150mm, are larger than females which do not exceed 135mm. The heaviest male on record was 550g while the largest female was only 400g.

The swamps in which the tortoise is found are temporary. In Perth's Mediterranean-type climate of cool, wet winters followed by hot, dry summers, the swamps contain water for only a few months each year. While the swamps still contain water the tortoises live in them, becoming active at temperatures over 14 degrees C and feed on living aquatic organisms including crustacea, insect larvae and small tadpoles. Unlike some tortoises, basking in the sun to raise body temperature is infrequent.

Copulation takes place in the water during winter and the females produce a single clutch of three to five hard-shelled eggs which are laid in November or early December. As with other tortoises the eggs are laid in an underground 'nest' dug a few centimetres below the surface. The hatchlings, which are only 29mm long and weigh about 6g, emerge in May or June, about 180 days after the eggs are laid.

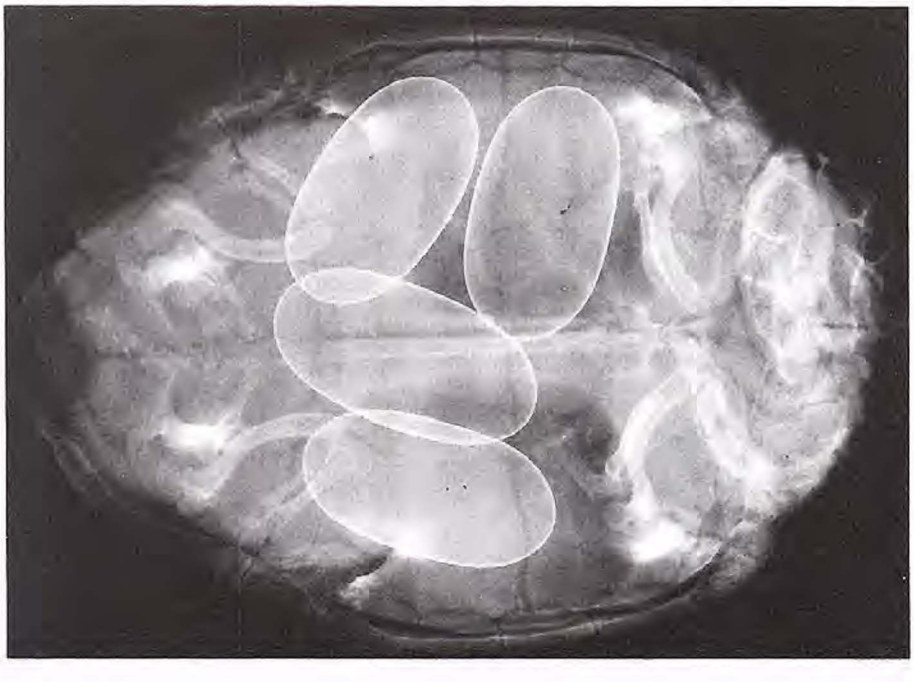
Because of the seasonal nature of the swamps, growth rings occur on the scutes (external scales of the shell) at yearly intervals (although there may be no growth in low rainfall years). When each tortoise is handled, information is recorded on size, growth rings and locality. Over a period of years a picture is built up of growth and movement.

Western Swamp Tortoises are difficult to find but, fortunately, the growth rings enable accurate estimates to be made of the amount of growth in past years. Adults have no growth rings since they gradually disappear when the scutes peel off, in the same way as other reptiles shed their skin from time to time.

Growth is slow and most occurs in spring and early summer when the water is warm and food is abundant. Sexual maturity is reached at around 120mm carapace length which takes about ten years under average conditions.

In the years of low rainfall when the swamps do not contain water for long, most tortoises do not grow at all. Some tortoises appear to grow more slowly than others — some individuals have taken up to 15 years or more to reach maturity. The life span of the Western Swamp Tortoise is not known but it seems likely that they can survive many decades. Adult males continue to grow slowly throughout their lives and large tortoises are obviously very old.

At the onset of summer the swamps dry. What happened to the Swamp Tortoise during summer was a mystery until radio-tracking located them and lead to the discovery that they spend summer in aestivation (dormancy), either in naturally occurring holes in the ground (mainly at Ellen Brook) or under deep leaf-litter (at Twin Swamps). Temperature recorders showed that while summer shade temperatures sometimes rise above 40 °C and ground temperatures in the sun exceed 60 °C and occasionally reach 70 °C, the temperature in the tortoises' tunnels or leafy refuges was usually between 20° and 30° and did not exceed 34 °C. Western Swamp Tortoises can withstand temperatures bet-



Radiograph of a female showing the eggs ready to lay.

ween 42°C and 43°C so high temperatures during aestivation do not cause any problems.

Although reptiles are often described as having skins impermeable to water this is not the case. Like all animals which live out of water, tortoises desiccate, losing water both through the skin and via the lungs. The Swamp Tortoise appears to have evolved a means of reducing cutaneous water loss, by having horny scales on the neck and limbs. Although the Western Swamp Tortoise still loses water in dry air, it is at a much slower rate than all the other Australian tortoises barring the Plate-shelled Tortoise, *Chelodina steindachneri,* an occupant of ephemeral pools in the arid parts of the north-west of Western Australia.

Desiccation in wild Swamp Tortoises was measured at Twin Swamps Nature Reserve by weighing transmitter equipped adults at the beginning and end of summer. Weight loss, of between 5 and 7.5 per cent, was well below the lethal limit of around 35 per cent. Dessication rates, however, increased in the smaller animals because of their relatively large surface area.

In years of average rainfall when water is present in the swamps for five or six months, hatchling Swamp Tortoises grow to around 40g before summer. Tortoises of this size lose between 25 and 28 per cent of their body weight by desiccation during their first summer aestivation. This proves to be a tolerable amount.

In years of low rainfall the swamps at Twin Swamps Nature Reserve may contain water for less than two or three months and the hatchlings growth is retarded. A 15g tortoise, which is the size reached in the drought year of 1966, would desiccate between 40 and 45 per cent — well over the tolerable amount — and no hatchlings survived that year. At Twin Swamps it seems that hatchlings must reach at least 25g during the first few months of life if they are to survive. At Ellen Brook Nature Reserve, where aestivation takes place underground, desiccation is not so severe, and here tortoises as small as 17g have survived the summer.

Counting wild animals accurately is always a problem and the difficulties are increased when they are rare and hard to catch. In the case of the Western Swamp Tortoise estimates are a little easier to make because of the long period of sampling (since 1963) and the ability to age animals from their growth rings. Calculations of population size are made with the aid of a computer using 'mark and capture' models.

At Twin Swamps Nature Reserve numbers have declined from over 100 in the mid-1960s to approximately 20 by 1977 and near zero today. At Ellen Brook Nature Reserve a population of 20—25 animals in the mid-1960s remains the same today. This means only about 25 Western Swamp Tortoises remain in the wild. The total population numbers between 45 and 50 as there are 22 captives at the Perth Zoo.

Juvenile Western Swamp Tortoise.

There is no single, simple reason for the rarity of the Western Swamp Tortoise. In fact several factors combine to exacerbate the problem.

Past and Present Range. Available records indicate that the range at European settlement was roughly an area of only 100 to 150 square kilometres on the coastal plain to the east and north-east of Perth and centred on the Swan Valley. This was the first part of Western Australia used for agriculture following the settlement of Perth in 1829. Now almost all of it is cleared and drained, and either urbanised or used for intensive agriculture. The two nature reserves are near the extreme northern end of the Swamp Tortoise's range and may not include the best or even the typical habitat. Together they encompass perhaps 1.5 per cent of the previous range. For a number of reasons, elaborated below, it appears that Ellen Brook Nature Reserve provides a better habitat than Twin Swamps. This reinforces the suggestion that the Western Swamp Tortoise's preferred habitat was the clay soils of the Swan Valley.

Fecundity. One clutch only, of three to five eggs, is produced. This is many fewer eggs than other Australian side-necks, most of which produce clutches of over 10 and up to 25 eggs and lay more than one clutch per year. The size

A hatchling next to its mother.

of Swamp Tortoise's eggs is comparable to those of other side-necks so the small size of the female means there is simply not enough space inside her shell for a larger clutch to be produced. This is accentuated by the female Swamp Tortoise being smaller than the male; the reverse is true in all other Australian side-necks.

Growth. Growth is very slow, mainly because the conditions for rapid growth are available for only a short time each year. A time of ten to fifteen years or more to sexual maturity is extremely long for such a small animal.

Drought. At Twin Swamps Nature Reserve two successive years of mean or above mean rainfall are needed for recruitment to take place — the first eggs are produced in the first year and the hatchlings must grow to a size to enable them to survive summer desiccation in the second year. In recent times Perth has suffered many years of below average rainfall, culminating in the lowest five year rainfall period (1976 to 1980) on record. The only two year runs of mean or above mean rainfall since 1963 have been 1963—64, 1964—65, 1967—68 and 1973—74. As a result natural recruitment has been very low.

At Ellen Brook Nature Reserve low rainfall has a lesser effect on the time the swamps are flooded and summer desiccation is less. Here recruitment occurs most years and appears to be unaffected by drought.

Predation. Little is known about the importance of predation of the Western Swamp Tortoise. Predation by the European Red Fox does occur and no doubt dingoes and dogs are also capable of killing and eating tortoises, especially when they are out of the water. At Twin Swamps foxes are abundant and it is thought that predation is a major factor in reducing the number of tortoises. Attempts to control foxes have failed because any foxes killed are quickly replaced by others living in the surrounding countryside.

At Ellen Brook Nature Reserve, where aestivation is in underground tunnels, predation is probably not such a major factor.

Fire. Western Swamp Tortoises aestivating under leaf litter at Twin Swamps Nature Reserve appear to be exposed to summer bush fires. Parts of the reserve were burnt in January 1962 and in January 1973. After the 1973 fire, the burnt area was searched for dead tortoises but none were found. One live tortoise was, however, picked up by a fire crew while it was crossing a firebreak ahead of the fire, so it would seem that some tortoises, at least, can escape fire. Fires also remove the leaf litter so important for aestivation and it takes three or four years for litter levels to build up again.

At Ellen Brook Nature Reserve fire does not affect the tortoises because they aestivate underground.

An examination of the reasons for rarity will show that, of the two populations, the one at Twin Swamps Nature Reserve is more likely to be affected than the one at Ellen Brook. Indeed, the Twin Swamps population has declined to extinction during the past decade. The Ellen Brook population is a small one occupying a very small area and, while holding its own, does not seem to be increasing in numbers. Were some natural or man-made catastrophe to happen at Ellen Brook the Western Swamp Tortoise would be reduced even further.

What can be done in such a critical situation? The only hope of helping the species recover seems to rest with captive breeding.

The Western Swamp Tortoise has bred successfully at Perth Zoo with no help or interference from man. However breeding success is low and, so far, only one animal has been raised to maturity. Recently, experimental work aimed at increasing breeding success was carried out at the Western Australian Wildlife Research Centre. This involves inducement of egg laying and artificial incubation of eggs, followed by hatchling husbandry. Up to now few hatchlings have been produced but many techniques have been learned. It is yet too early to say whether captive breeding will be able to prevent extinction. If it does, the next step will be to release animals into the wild, but this is many years away.

If it doesn't sting, it itches

by Roland Hughes

Bather's Itch, also known as Pelican, Tuggerah, Toukley or Weed Itch, as well as Schistome or Marine Dermatitis, is an extremely unpleasant affliction which, at one time or another, will affect most Australians who swim or wade in coastal lagoons and lakes as well as the sea around Australia.

Every summer the Museum is inundated with calls and visits from worried victims wanting to know what has 'bitten' them and caused the itchy, raised red lumps all over their bodies.

In fact, rather than being 'bitten', the skin has been penetrated by a number of microscopic fork-tailed larvae of the flatworm, *Austrobilharzia terrigalensis.* Some larval stages of this worm develop in the small Sydney Welk, *Velacumantus australis,* and the adults are found in the blood vessels of birds such as gulls, ducks, swans and pelicans.

Often the victim feels a slight prickling on his skin, not unlike the jab of a mosquito, as the cercariae bore in. After 15 minutes this sensation subsides and a small red spot appears where each larva has penetrated. As soon as the larvae begin to burrow an intense local reaction occurs and the body produces antibodies which kill the larvae.

On death the larvae release a foreign protein which changes the red spots into annoying itchy lumps. These appear after a couple of days.

Each lump is about two millimetres in diameter and usually only becomes itchy if scratched or rubbed by clothes. Sometimes they can turn into blisters, surrounded by red halos as the whole area becomes inflamed. However, unless the lumps or blisters become secondarily infected from vigorous scratching and rubbing, they soon fade and a week after first contact with the larvae only small brown spots remain. These may stay on the skin for a month or more.

Although biologists are still not certain whether larvae only occur in summer, most attacks are linked to the heat. Often a series of very hot days cause the microscopic larvae to emerge from the tissues of their snail host and swarm on the water surface.

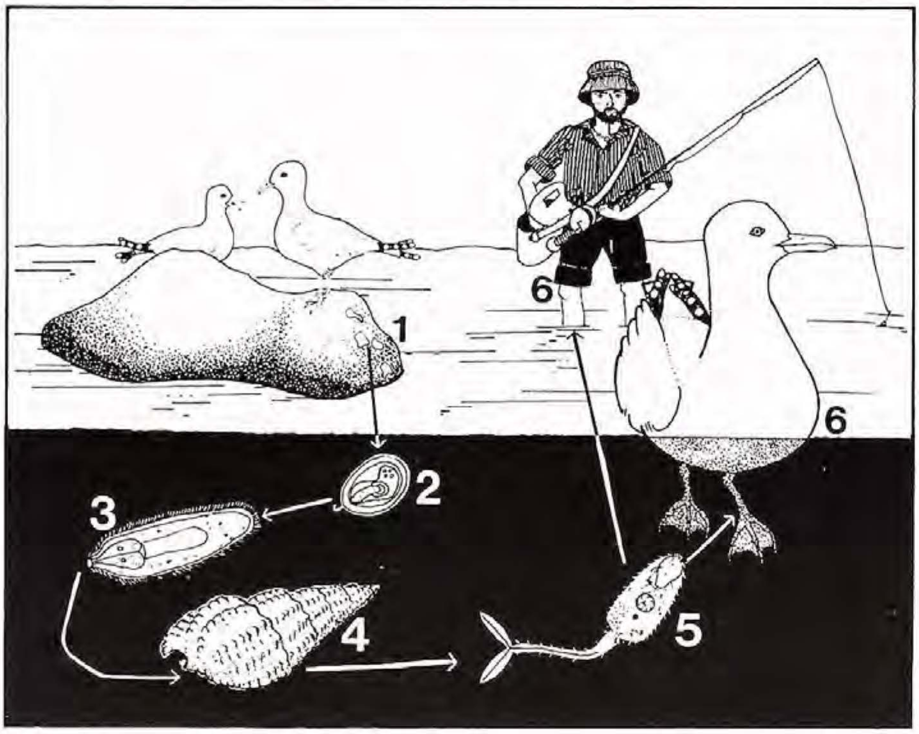
First discovered in the living blood vessels of a seagull from Terrigal, NSW, this flatworm inhabits the entire Australian coast.

They belong to an unusual group of blood flukes which generally gather in pairs, the longer thinner female enclosed in a canal-like groove extending most of the length of the male's body. Females project from either end of the canal and measure some five millimetres while the males are shorter and average 3.5 millimetres. Both worms have oral and ventral suckers which they use to cling to the blood vessel walls of hosts. Each sucker is armed inside with fine spines enabling the worm to maintain a strong grip on the blood vessel walls.

Effective first aid centres on the liberal use of phenolised calamine lotion. If the reaction is bad or infection results, it is best to see a doctor. He will prescribe antihistamine cream or tablets, anaesthetic cream or steroid ointments, antibiotic cream or broad spectrum antibiotics, as may be required.

The best way to avoid attacks of the larvae is not to swim in places where the roost sites of gulls and pelicans coincide with eel-grass tidal flats full of hundreds of welks.

The level of infestation of mud-dwelling worms by larval flatworms is very high near roosting sites. But because the larvae are not long-distance swimmers this high concentration tapers off rapidly, the further you move from the nest sites.



The life cycle of the Bather's Itch flatworm is complex and involves two hosts — one a seagull, the other a snail. Normally adult worms live in the seagull (1), and their eggs (2), are passed out with the bird's faeces. If the eggs reach water they hatch and a swimming larva (3), emerges. Should this larva encounter a whelk (4), it bores into the soft tissues and settles down to grow. From it develops another larval stage called a sporocyst, which proceeds to grow and multiply asexually, giving rise to more sporocysts, which in turn produce a generation of fork-tailed, swimming larvae called cercariae (5). These emerge from the secondary host, the whelk, and actively swim about in search of their normal final host, the seagull (6). A human (also 6) may accidently become involved as host to these larvae, which probably cannot distinguish between man and bird. The larvae penetrates the skin of the first one it encounters. However, if a human is infected the flatworm's life-cycle is broken, for, in the tissues of the host, the defence mechanisms of the body come into action and kill the larvae.

CENTREFOLD 1

Southern Elephant Seal

Mirounga leonina

by M. M. Bryden

Reaching a length of 3—4m and a weight of about 4,000kg, the male Southern Elephant Seal is the largest of the marine mammals; females are much smaller, with a maximum weight of about 350kg. It is a predator on squid, cuttlefish, octopus and fish.

Distribution is circumpolar, mainly in subantarctic latitudes, although individual records extend from 16°S to 78°S. Lengthy periods at sea are interspersed with regular haul-outs on subantarctic islands and parts of the antarctic continent, from which individuals appear to disperse randomly, rather than in a mass migration.

Breeding males come ashore in late August and distribute themselves over the beaches of such islands as South Georgia, Kerguelen, and Macquarie. They are followed by pregnant females which congregate in groups ('harems') within the territory of an older male which expends much time and energy defending the territory and — with less success — the integrity of the harem. The prominent proboscis or snout of mature males is a resonator that assists in production of the loud, bubbling roar with which one male challenges another.

The single pup born to each female in September or October is suckled for about three weeks and must thereafter fend for itself. It fasts for about seven weeks while its aquatic skills are maturing as it plays and swims in freshwater pools and shallows off the beaches, then goes to sea when about ten weeks old.

Mating usually takes place in the harem just before weaning is completed but a few females may mate in the sea, soon after leaving the harem. The ovum, fertilised about November, develops into a dormant embryo which is not implanted until about the end of February.

Females become sexually mature at 4—6 years of age, and live for 10—15 years. Males are sexually mature at about six years of age but do not attempt to mate until about 10 years old and are unlikely to control a harem before the age of 14. They live for 10—25 years.

Subfossil bone deposits show that elephant seals formerly colonised the north-western coast of Tasmania where they were eaten by Aborigines. A breeding colony on King Island in Bass Strait was hunted to extinction in the nineteenth century and heavy exploitation at Macquarie Island and other subantarctic islands well into the twentieth century led to a serious decline in total numbers. Apart from the birth of a pup on the west coast of Tasmania in 1958 and another in 1975, no breeding has taken place in Australia in this century.

Size: Total length is 3.5—4.2m for males and 2—2.6m for females. Weight is 2000—3800kg for males and 250—350kg for females. (Males of 6.5m and females of 3.5m length are known.)

Identification: In water, uniformly dark grey; on land, dark brown above, paler below. Older males distinguished by size and extensive scarring of the neck and proboscis.

Recent Scientific Names: None

Other Common Names: None

Survival Status: Abundant

Subspecies: *Mirounga leonina falclandicus,* Falkland Island; *Mirounga leonina macquariensis,* Macquarie Island, Chatham Island; *Mirounga leonina crosetensis,* Crozet Island, Kerguelen Island, Heard Island.

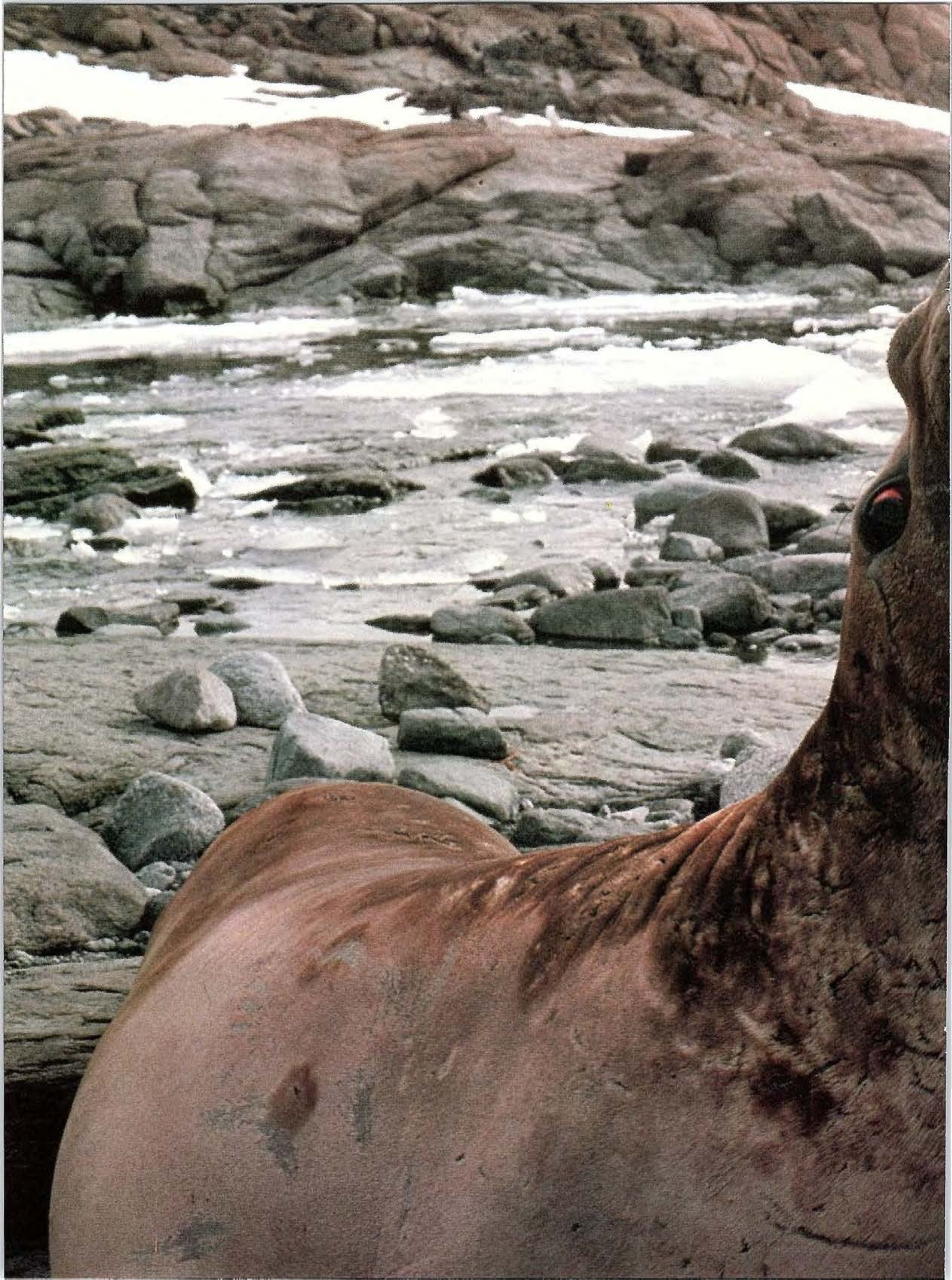
A young male Southern Elephant Seal. Males are sexually mature at about six years of age but do not attempt to mate until about 10 years old and are unlikely to control a harem before the age of 14.

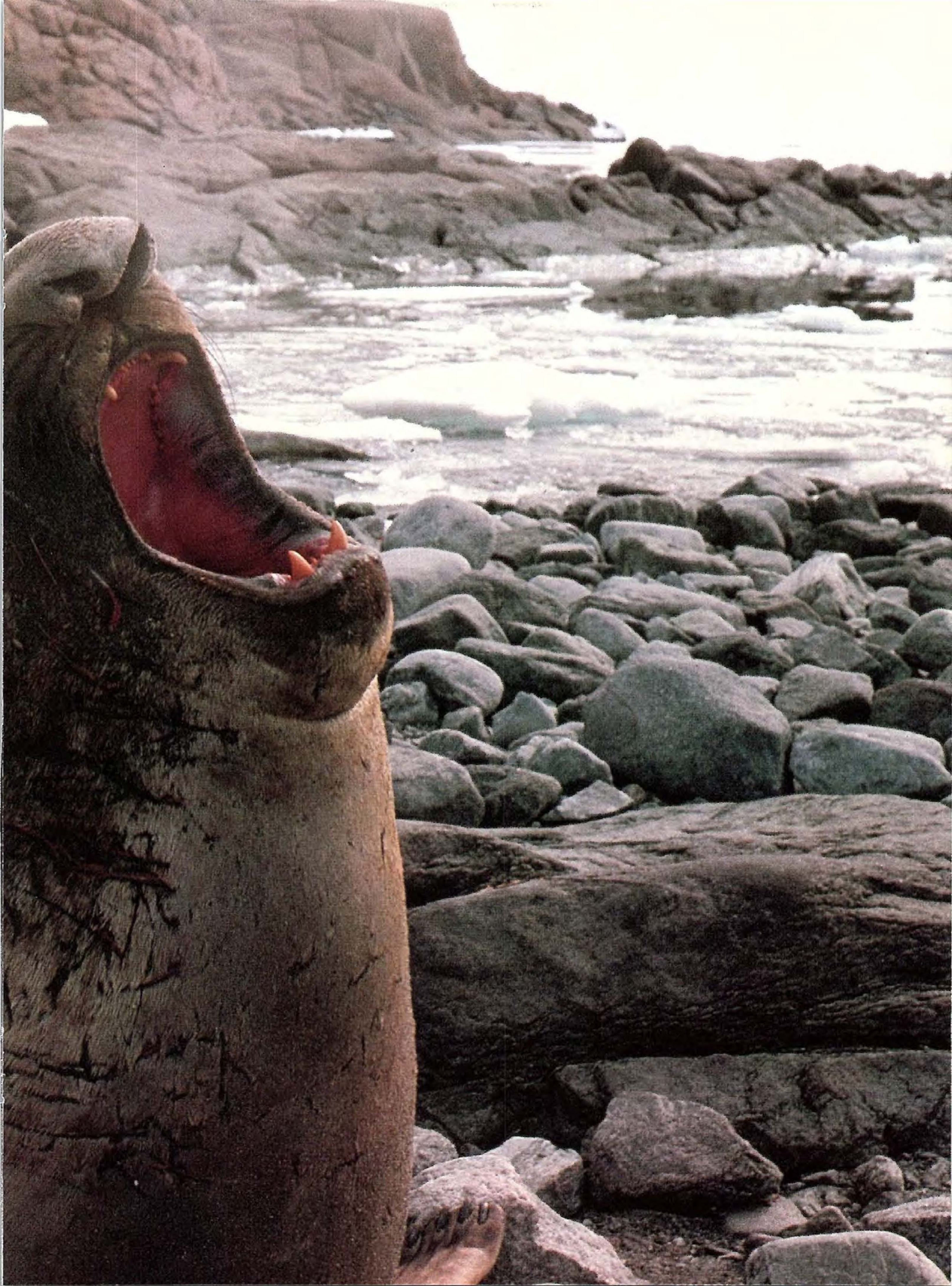
Centrefold (overleaf), breeding males come ashore in late August and are followed by the pregnant females which congregate in 'harems' within the territory of an older male. Photos G. W. Johnstone (NPIAW).

Further Reading

Carrick, R., et al (1962). Studies on the Southern Elephant Seal *Mirounga leonina* (L), I-V. *C.S.I.R.O. Wildl. Res. 7, 89-206.*

Extract from the forthcoming book, *The Mammals of Australia,* Ronald Strahan (ed.), Angus and Robertson, Sydney. This book includes an account of every species of Australian mammal and will be illustrated with colour photographs from the National Photographic Index of Australian Wildlife. Mike Bryden is an Australian authority on seals and is a Reader in Anatomy at the School of Anatomy, University of Queensland.





Elephant Seal harvesting

During the last century Southern Elephant Seals were 'ignorantly exploited' and 'indiscriminately slaughtered' almost to the point of extinction by sealers and profitmongers for its precious blubber oil. However, over time the breeding herds recovered and biologists now agree that this seal, of all the Australasian species, cannot only withstand controlled harvesting but benefit from it.

Studies of the Macquarie Island population of Southern Elephant Seals conducted during the early 1960s first revealed the feasibility of harvesting.

Biologists concentrated on two groups within the population — adult males and weaned pups. They found that the only way sealers could harvest adult males was when they first appeared on the beaches for breeding or during moulting.

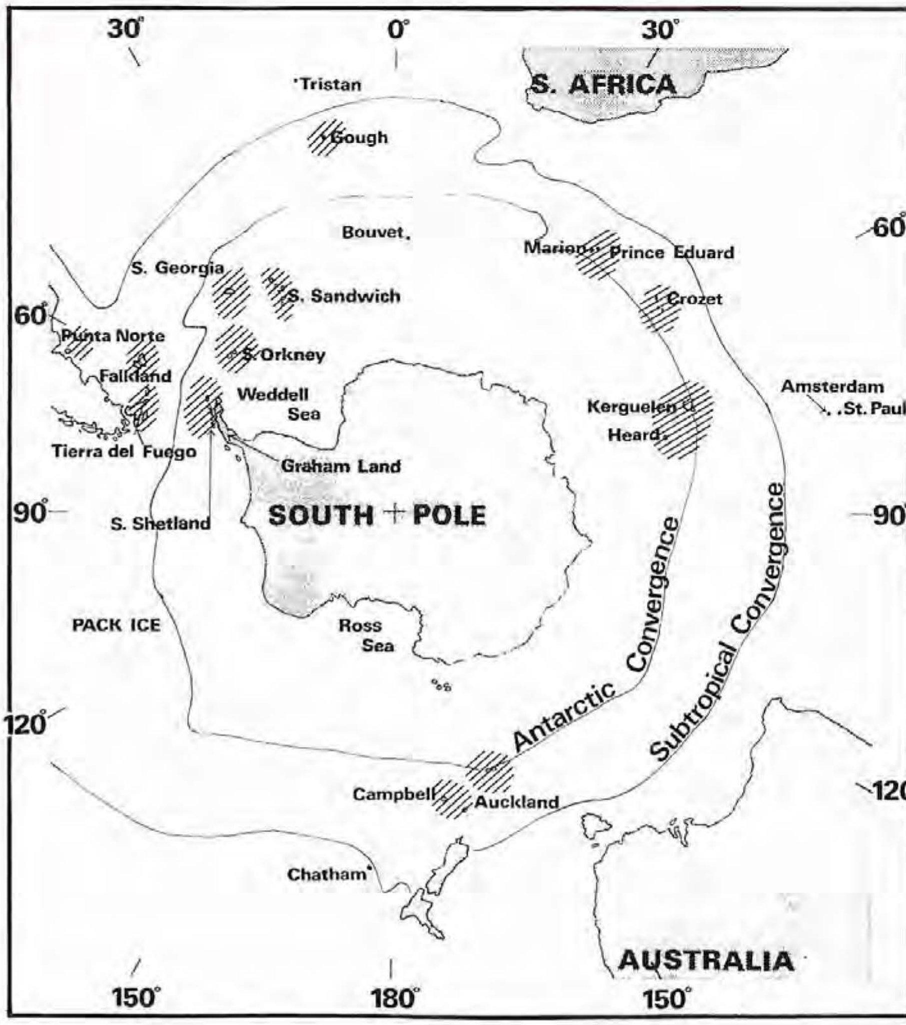
Harvesting during breeding was ruled out because it would severely distress both the pregnant females and those suckling their young. It would also have a dramatic effect on the reproductive rates of the colonies because as is often the case, only the prime bulls would be culled.

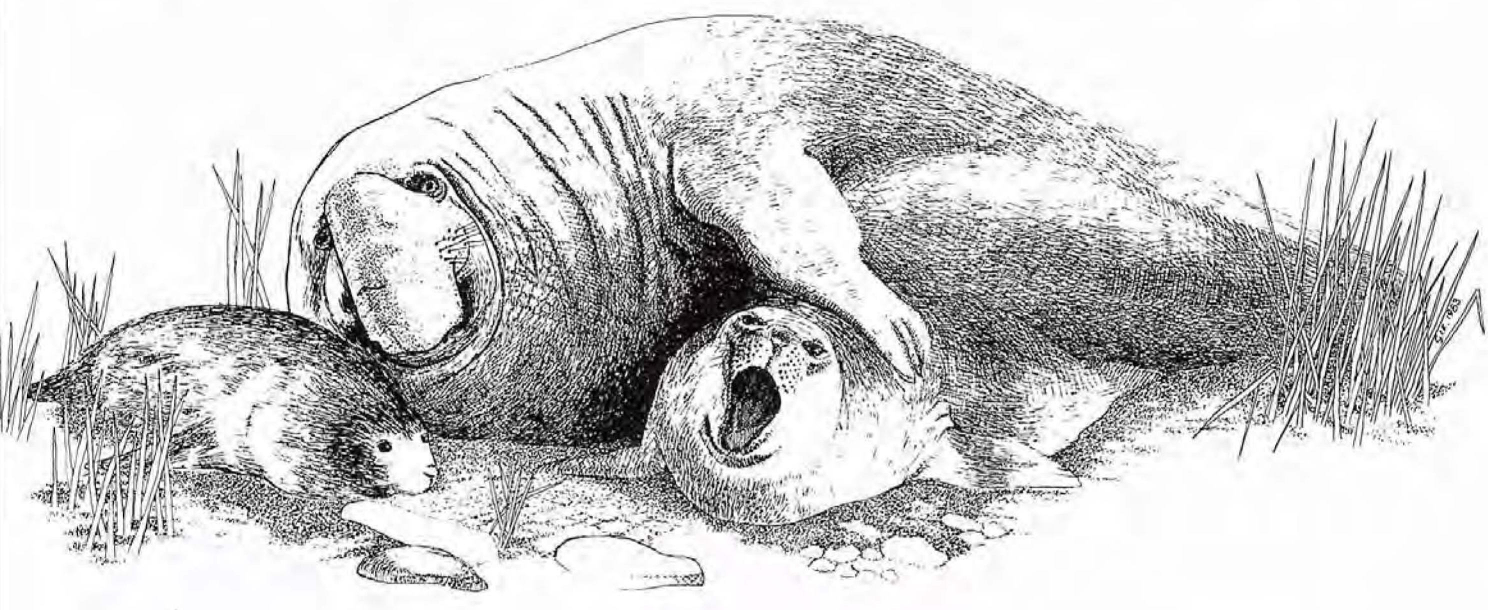
To harvest adult males during moulting, a period when the Southern Elephant Seal carries its maximum blubber reserves, was also ruled out. Moulting never occurs at a set period and the males would be intermingled with seals of all ages and sex.

At this point in their studies biologists turned to the weaned pups to see if they provided the answer.

Not only were they an effective solution to the harvesting problem but biologists found that 80 percent of male and 50 percent of female weaned pups could be taken as they left the harem without even affecting breeding stocks.

Further studies will probably confirm that harvesting could be a distinct advantage to the population of Southern Elephant Seals. Strictly controlled and properly managed harvesting of weaned pups would allow developing females greater food resources, enabling them to breed at puberty as well as dramatically increasing their survival rate. — **Roland Hughes.**





Death of the Murray

by Keith Walker

The Murray River, the world's fourth largest and Australia's only great river system, is on the brink of destruction. European man's desire to control the Murray's flow pattern has brought devastating change to native plant and animal communities as well as altering the character of the river itself.

Originally called the Millewa, by Aboriginals that lived alongside its banks 40,000 years ago, the river's name was changed after European man arrived in the 1830s. By 1870 goldminers had moved into the river valley, closely followed by settlers with their crops and stock. Then in 1870, irrigation was introduced and the pattern for use of the river over the next 100 years was set.

In this article, Keith Walker, a Senior Lecturer in Zoology at the University of Adelaide and an ecologist whose research centres around the Murray river, provides an overview of the use and abuse of this famous natural resource.

Natural flows in the Millewa changed with the seasons, themselves open to variation between years. Successive wet and dry periods could bring floods or droughts which would completely change the appearance of the river and surrounding countryside. The fact that they occurred, however, was perhaps less significant than their irregularity.

Leaving its mountain tract, robbed of most of its downhill run, the river spread forth as a maze of meandering waterways and billabongs. It deposited much of the sediment transported from the headwaters catchment, building a floodplain of silt, sand and clay within a broad valley. The valley extended seaward until it came to a region where, realigned by geological faults, the river turned to enter a deep limestone gorge. Beyond, shallow lakes impeded the river's final passage through a shifting, sandy channel to the Southern Ocean.

Despite its beauty in places, the Murray River is in serious trouble. Since water storages were built, water flow regulation has drastically curtailed regeneration of river red gums. Photo John Fields.

Death of the Murray

The riverside land was a corridor through an inhospitable landscape. Despite an ultimate dependence on the river, the floodplain communities evolved to meet the vagaries of flow. The plants and animals could withstand difficult periods by exercising their powers of tolerance, by lying dormant or perhaps migrating elsewhere. When good conditions returned, as with drought-breaking rains, they were prepared to utilise them quickly and efficiently. Opportunism was the key to survival — the river had a nomad's rhythm.

Aboriginal people lived in the region forty thousand years ago. For man, as other animals, the Millewa was comparative security and comfort in a forbidding environment. It yielded water, wood for shelter, cooking fires and weaponry, bark and reeds for canoes, baskets and other utilities, plants, fish, waterfowl, mussels and yabbies as food, and a host of other resources. Surplus could be traded, extending the river's influence to remote inland areas. Above all, the Millewa figured in spiritual traditions. It was the Provider, past, present and future — totems, rituals and ceremonies were celebrations of the river community.

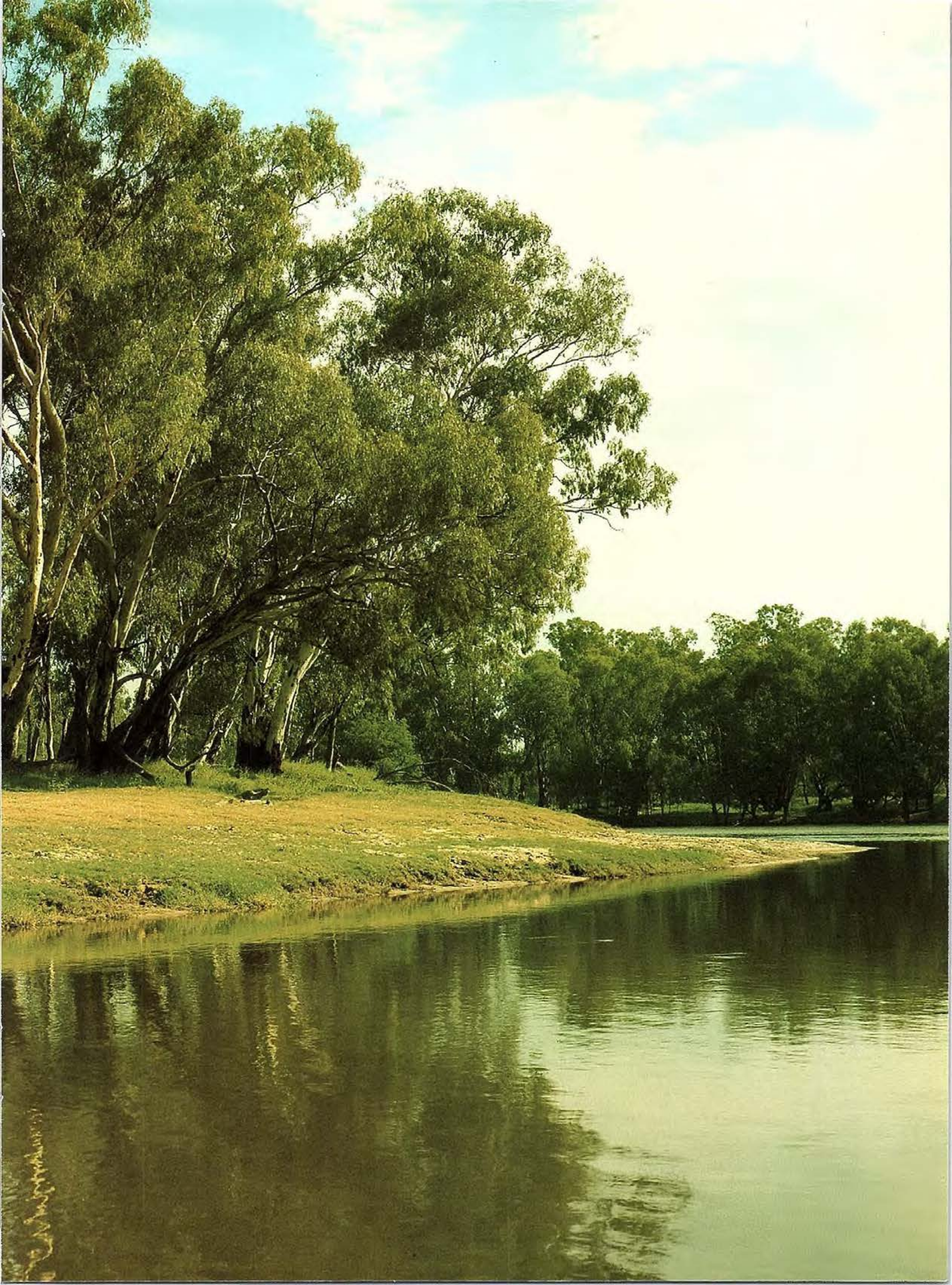
But the river's harsher moods bore no favours, and life could not have been an idyll for the river people. Survival demanded endurance, ingenuity and adaptability. Forty millenia are a measure of their skill.

The impact of Aboriginal man on his environment was not insignificant. His widespread, persistent use of fire greatly affected the riverland forests and grasslands. Plants of many kinds were harvested. The size and contents of still-intact riverbank middens attest to an active, productive existence as hunters and gatherers. If Aboriginals lived in harmony with nature it was not without effect, and less by choice than necessity. They were subjects of the Millewa, without the pretensions of masters.

Australian prehistory ended in 1788. There began a new era, directed by men with a vastly different perception of their place in nature. In the vanguard of invasion, explorers like Thomas Mitchell found a country of great promise. Near Swan Hill in 1839, he mused:

Above, part of Lake Hume created by the Hume Dam. Built in stages from 1932—61, the reservoir flooded the former confluence of the Murray and Mitta Mitta Rivers. Below, the Aboriginal fish-trap at Brewarrina on the Darling River, an ancient form of damming. Known as Ngunnhu by the Aboriginals, the fish pens were built of stones and varied greatly in size. During the early spring months when fish travelled upstream in immense numbers the stone pens would trap many of them.

Opposite, the Murray River at Tocumwal. Photos courtesy of the NSW Department of Tourism.



Death of the Murray

"A land so inviting, and still without inhabitants! As I stood, the first European intruder on the sublime solitude of these verdant plains, as yet untouched by flocks or herds; I felt conscious of being the harbinger of mighty changes; and that our steps would soon be followed by the men and animals for which it seemed to have been prepared."

Despite his presumptions, Mitchell was a perceptive naturalist, his journal a precious record. But beyond the river's green fringe, the landscape was, for many of the invaders, a wasteland. Travelling the Lachlan swamps in 1820, John Oxley wrote:

"There is a uniformity in the barren desolateness of this country, which wearies one more than I am able to express. One tree, one soil, one water, and one description of bird, fish or animal, prevails alike for ten miles, and for one hundred. A variety of wretchedness is at all times preferable to one unvarying cause of pain or distress."

Even so, spurred by encouraging reports from Hume and Hovell, Sturt, Mitchell, Hawdon and others, the usurpers moved quickly to establish their claims to the land. For the Aboriginal tenants, resistance was futile — their destruction was brutal and sudden.

The Millewa's cultures and traditions are mostly lost, although vestiges remain in the early chronicles of Angas, Beveridge, Eyre, Taplin and others. In 1857, less than a generation after the invasion, surveyor William Blandowski reported:

"... I have but the most deplorable statements concerning our natives. Extermination proceeds so rapidly that the regions of the Lower Murray are already depopulated, and a quietude reigns there which saddens the traveller who visited those districts a few years ago."

The Millewa became the Murray. Europeans were quick to recognise the river's resource potential, especially for riverboat transport and irrigated agriculture. By controlling the river's flow, it was possible to have year-round riverboat traffic and reasonably assured supplies for irrigated crops. The new-found river could be made the Mississippi and Nile of Australia.

The commercial riverboat era has since passed, but irrigation reigns supreme, if not secure, with other agricultural, industrial and urban enterprises all requiring predictable water supplies, so bolstering the need for more flow control.

We seek to control a flow pattern that is inherently unstable. This is a profound change for the native plant and animal communities, and disastrous for most, because it has altered the river's essential character. With regulation has come an array of physical and chemical pollutants, and many exotic plants and animals. The land has been cleared and replanted or laid waste. We have attempted to recast the river in a mould better suited to the needs of an industrial society.

Dams are the main instrument of flow control. The Hume Dam impounds the Murray itself, and there are many tributary storages, including Dartmouth on the Mitta Mitta River, Eildon on the Goulburn and Burrinjuck on the Murrumbidgee. Control is further enhanced by weirs, levees, barrages and off-river storages. The river system carries more than 100 impoundments, and more are planned. More than nine-tenths of the system's annual flows are committed to use, and for months on end the Murray no longer flows to the sea.

The Hume Dam dominates the river environment near Albury. It delays headwater flows until they are needed for irrigation, so that high rivers now occur in summer rather than winter. Water released to the river comes from the bottom of the reservoir, and is relatively cool—seasonal river temperatures now span 10—21C rather than 7—24C. There is also a lag, with temperatures a month or so out of phase with the seasonal pattern.

Oxygen in the deeper waters of the reservoir is gradually lost through summer, and hydrogen sulphide and other chemicals are liberated from the bottom muds, making the water poisonous to fish and other aquatic animals. With release through the dam, an oxygen 'sag' is transmitted downriver. These effects persist for many kilometres downstream.

There are other changes associated with operations at Hume Dam. Bank erosion and siltation, for example, are products of regulated flows in a channel once inclined to braid and meander, as the river met with the first of its plains tracts.

The outcome has been to discourage native fish. Freshwater Catfish, and originally Golden Perch too, disappeared from the Albury region because there are no longer the 'warm-flood' conditions necessary for spawning.

The problem is compounded by Yarrawonga Weir, some 200 river-kilometres away, because the weir lacks a fishway and so prevents recolonisation from downstream. Recently, hatchery-reared Golden Perch and other native fish have been released in the region. Continued restocking may help to compensate for the general devastation of native fish populations.

Weirs along the Murray have other important effects. Relicts of the riverboat era, they are now used mainly to 'fine tune' flow regulation, although they have belatedly realised some service to navigation with the boom in tourist boats. Passage through the lock accompanying each weir involves a change in water level of about three metres.

There are 13 weirs, ten so near one another that the lower Murray is but a series of pools. This has discouraged river-adapted animals, like the River Mussel, *Alathyria jacksoni* and Murray Crayfish, *Euastacus armatus,* but created new habitats for their floodplain counterparts, the Billabong Mussel, *Velesunio ambiguus,* and Yabbie, *Cherax destructor*. River-floodplain complements are recognisable among other members of the flora and fauna and their significance is obvious — the Murray is indivisibly a floodplain river.

Riverbank levees bar the Murray from its floodplain, further tightening flow control, protecting townships and swamplands reclaimed for pasture and farmland. They are erosion-protected by planted willows, fast-spreading trees that now dominate the riparian land in South Australia, crowding the native species.

Flow control by dams, weirs and levees has limited the extent and frequency of flooding, isolating the floodplain from the parent river. As flooding is limited, so must the floodplain environments—forests, billabongs and wetlands—become more restricted. Without its floodplain, the Murray is a canal—the ideal, perhaps, of an insouciant water resource engineer.

Throughout its evolution the Murray has been subject to salt inflows from underlying marine sediments. In our times, irrigation has brought the saline groundwater nearer the surface, increasing salt accession to the river. The weirs also contribute increasing salt loads through pressure on aquifers. Irrigation return water is another source. The river is now sometimes too salty for crop plants (beyond about 600 parts per million). The problem threatens the already-troubled irrigation industry unless remedial measures are effective. These include engineering works to divert saline drainage from the river, limits to the size of planted areas and changes to methods of irrigation.

Other water users are affected. High salinities in domestic and industrial supplies cause corrosion and scaling in pipes, boilers and heaters, increased fabric wear and, according to some evidence, effects on human health. The costs are millions of dollars annually.

Curiously, salinity may not affect the aquatic plants and animals, at least not conspicuously. The fish and invertebrates of the river seem able to withstand salinities a good deal higher than those now prevailing. Yabbies and even Murray Crayfish, for example, can tolerate twenty or thirty times the river concentration for short periods.

The Murray is at once a sewer and a water supply. People often malign the river's water quality, referring to its sometimes unpleasant taste, odour and muddiness, and to chemical contaminants including sewage, agricultural fertilisers, heavy metals and pesticides. The problems intensify with distance

downriver, and in South Australia — where the bill for neglect must be paid — there is apprehension at what might be the quality of future supplies.

Most valley towns and cities discharge effluents to the river. Sewage (with agricultural runoff) is a major contributor of plant nutrients (nitrogen and phosphorus), the ingredients of eutrophication, and often the cause of unpleasant algal growths. Although nitrogen and phosphorous levels are more than sufficient, blooms are not so common in the Murray, probably because the muddy water admits too little light for unrestrained plant growth.

The muddy water, then, may have some virtue. But the presence of so much suspended sediment betrays rapid erosion from the catchment, a legacy of overzealous land-clearing, overgrazing and other agricultural malpractices. The lost topsoil becomes the silt in the main river channel. Silt is an increasing problem for navigators. It has sealed the deeper holes in the channel of the lower river, depriving Murray Crayfish of their refuge.

Heavy metals like cadmium, copper and zinc are associated with industrial wastes and sewage, or are contributed by the catchment rock. Because freshwater mussels and certain other river animals are directly exposed to heavy metals and other pollutants, it is possible to monitor the contamination by making observations of the animals themselves. 'Biomonitoring' often has advantages over the more conventional methods of chemical assay. Although some preliminary surveys have been made, no-one yet knows whether heavy metals represent a serious problem.

Pesticides are used freely throughout the Murray's watershed, and it would be surprising if they have not affected the river plants and animals. Isolated checks have been made, but again no-one really knows whether a problem exists.

Most of the Murray's two dozen or so fish species are less common and widespread than they once were. Species like the Trout Cod, Blackfish and Macquarie Perch are now mostly restricted to tributaries, and the Trout Cod particularly is believed to be in danger of extinction. The Murray Cod, prime fish of the river, is much less common than formerly. Bony Bream and Golden Perch are now the only native species with real commercial significance, and these too have suffered declines in range and abundance.

Murray and Darling Rivers meeting at Wentworth. Photo John Fields.

Putting aside the problems of management, the causes of the decline are a combination of environmental changes, interactions with exotic fish species and perhaps overfishing. Dams and weirs change flooding and temperrature patterns in ways inimical to most species. Siltation affects species that spawn among gravel. Schemes for 'river improvement', are implicated. Pollution is another factor.

At least nine exotic species are established in the Murray, among them trout, Redfin, Mosquitofish, Goldfish and the Carp. The effect of trout is shown by the thriving native fish populations that occur in the few areas where trout have not penetrated.

The invasion of Carp in the 1970s was viewed with great concern, but their environmental effects are unclear. Carp now rank with the most valuable commercial species in the river.

Continued fishing during a succession of dry years (when spawning is inhibited) could deprive fish populations of their capacity to recover quickly when favourable conditions return.

In the early 1960s newly introduced trolling lures provided anglers with large catches of Murray Cod. A severe drought in 1967—1968 further contributed to a decline in cod numbers. Whereas catches in South Australia in the mid 1950s were around 100 tonnes annually, they were down to two to three tonnes in the early 1970s. The most recent statistics suggest that only now there may be the beginnings of a recovery.

A formidable array of exotic plants and animals have been introduced, to the Murray environment. Some emerge as pests and it is enough to list a sample. Among the animals—goats, pigs, cats, foxes, rats and mice, dogs, rabbits, sheep and cattle have all left their mark. Among the plants there are willows, various other trees and shrubs, and a host of grasses and agricultural weeds. In their wake, most native species have declined. The situation is far from stable, and it may well be that we have committed several native species to ultimate extinction.

Desirable or not, these exotica are here to stay, and eventually there must come a time when we cease to recognise them as such. With their irrevocable presence, more than any other of our actions, the biological character of the Murray ecosystem has been revolutionised, and its evolutionary future redirected.

The transition from Millewa to Murray has been catalysed by development in the service of irrigation. It has been, and is, overseen by people of good intentions, but with a tragically blinkered regard for needs other than flow regulation.

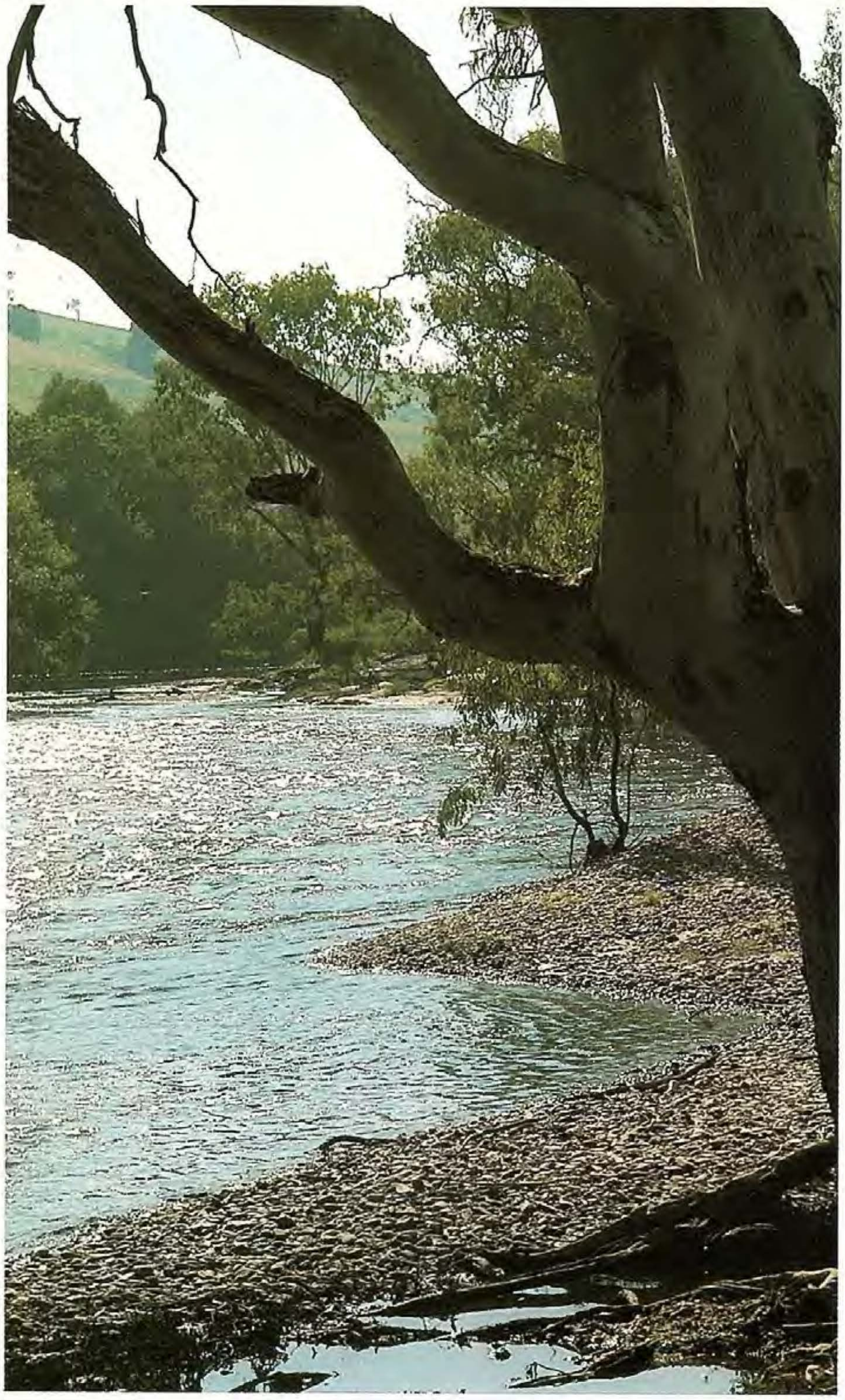
Other legitimate users of the river resource have few if any guaranteed rights. Conservation, properly an umbrella for management of the entire river basin, is seen as a minority interest.

Our political founders imposed their view of the Murray resource upon us. Yet the days of colonial expansion are gone and modern Australia faces the necessity of resource husbandry, with an eye not to an unlimited future but to maintaining an equilibrium.

We have a Federal Constitufion that 80 years ago placed responsibility for the Murray-Darling system irretrievably in the hands of four self-minded states. River management hinges upon an interstate water-sharing agreement, devised in the riverboat era and excruciatingly slow to adjust to changing needs. Our 'band-aid' system of big-river government is an ecological absurdity.

In another dimension, we have scarcely begun to understand the ecology of the river system. If a central governing authority were established tomorrow, it would have no knowledge with which to begin its task. Yet we are utterly dependent on the river's capacity to supply our demands and absorb our insults. It is the kind of nonsense that only a bureaucracy could sustain.

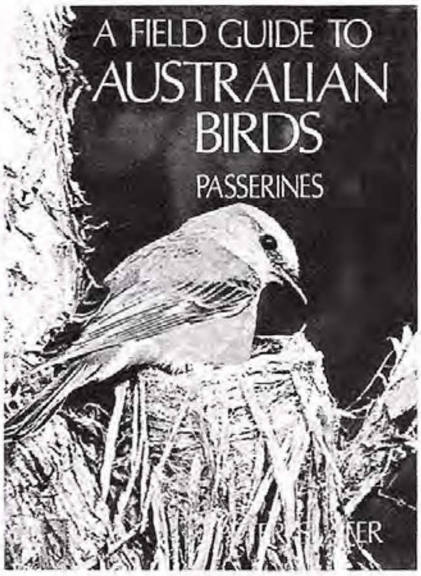
A device we have to guard the real world against ourselves is to reserve land for 'conservation' — by creating islands of nature, we seek to maintain a balance. Yet along the entire length of the Murray there is but one small National Park and a scatter of conservation parks and wildlife sanctuaries. No-one can say quite how many or, more importantly, how effective they are. Is this a barometer of government concern?



More than half a million Australians depend on the waters of the Murray in their day-to-day lives. It is too valuable a resource to lose. Already whole populations of native fish, plants and the 1,000 year old red gums have been severely affected. Photo courtesy of the NSW Department of Tourism.

IN Review

Field guides to the birds of Australia



The lack of a good field guide to Australian birds despite the release of a number of books attempting to fill this gap in recent years is annoying and a little surprising. When I first attempted to use what was Australia's one and only guide before 1970, Neville Cayley's *What bird is that?* to identify birds, I quickly discovered that the birds couldn't read the book and insisted on frequenting habitats where they didn't belong. Even when bird, book and habitat coincided, the dismal quality of the plates prevented easy identification. As a result Cayley was relegated to the bookshelves.

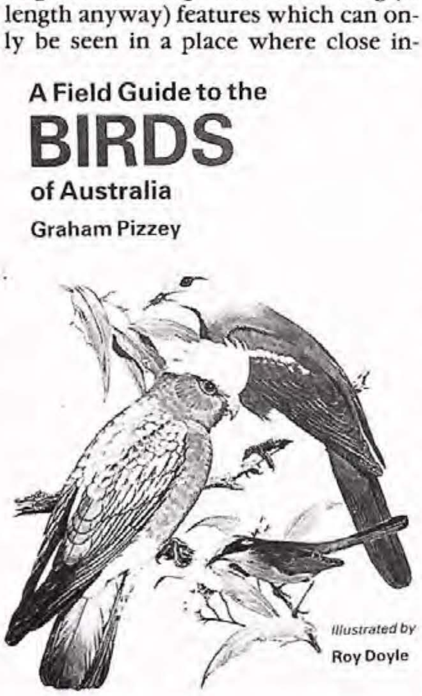
About the time that I gave up on Cayley, I was introduced to an absolutely superb book by Keith Hindwood and Arnold McGill, *The Birds of Sydney.* Although the book has no illustrations and didn't pretend to be a field guide, it has good descriptions of the birds likely to be found near Sydney. Covering nearly 400 species or half the Australian avifauna, the book has many of the attributes of a good field guide — concise, easy to carry, clearly written, follows taxonomic order and contains good descriptions. All it lacked were good diagnostic plates. Today, it is still the only field guide to Australian birds and it is most unfortunate that copies are virtually unattainable.

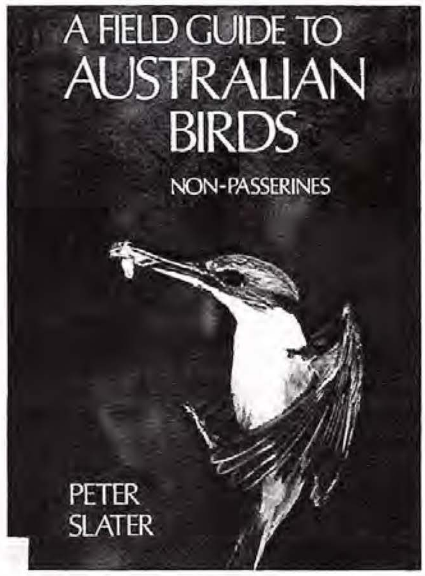
Ten years has seen a vast improvement in the quality of Australian ornithology. There has been increased amateur involvement in research and a gradual coming together of bird watchers and biologists. This change has occurred in conjunction with a proliferation of books about Australian birds. At least two of these lay claim to being field guides to the birds of Australia.

The first to appear was the two volume work by Peter Slater, *A Field Guide to Australian Birds.* The first volume deals with non-passerines and was published in 1970 while the second on passerines was a long four years later. Pizzey's *A Field Guide to the Birds of Australia* appeared in 1980.

What should a field guide be? To begin with it should have all those features which makes *The Birds of Sydney* invaluable — conciseness, clarity of expression and correct taxonomic order. It should also fit into a back pocket, have a soft cover, be reasonably water repellent and well bound to withstand hard use. Identikit pictures are almost secondary, but good diagnostic plates do make the life of a bird watcher easier.

Ideally, plates should illustrate the main features by which a bird can be identified as it flies away, hides behind leaves or appears just as the sun is setting. There is no point in describing (at length anyway) features which can only be seen in a place where close in-





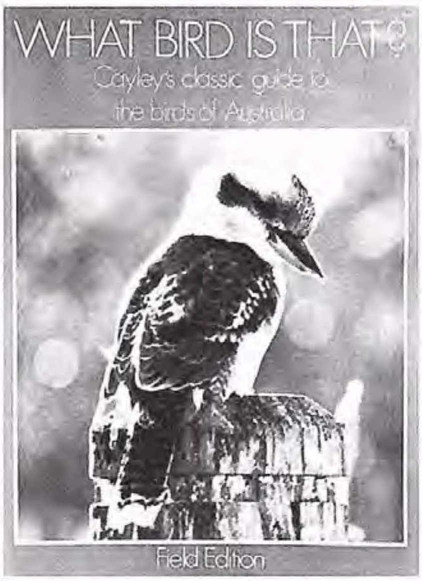
spection can take place, for example, the Museum's bird gallery.

Although Slater and Pizzey obviously consider their books to be field guides I believe they are best described as mini-handbooks, references to adorn one's desk until a proper handbook of Australian birds is produced. Why don't I consider them to be field guides?

Slater's *A Field Guide to Australian Birds* has the obvious disadvantage of being two volumes rather than one while the sheer weight of Pizzey's guide is daunting. Pizzey's book also suffers by being large and by the fact that many of the illustrations it contains are inadequate. Some are so poor that they cannot be used for field identification. Most birds illustrated in Pizzey's book appear stiff, lifeless and are posed in unlikely (not to say unnatural) postures. Moreover some plates are so crowded that the small size of the birds on the plates prevents accurate colour reproduction. The honeyeater plates in Pizzey are particularly bad in this respect. I found that when I first used the guide on a trip to the Northern Territory, I had to consult the range maps instead of the illustrations and narrow the options before I could identify the bird.

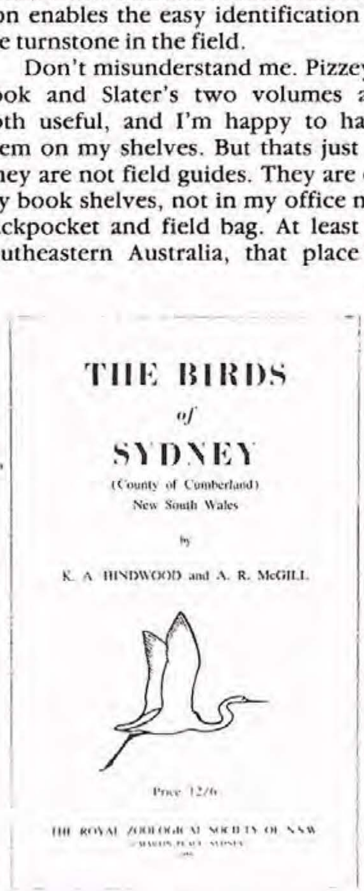
As field guides, Pizzey and Slater suffer by separating the text from the plates, and the maps from both. The best layout in a field guide is where text and range map face the illustra-

IN Review *continued*



tions. This cannot be done unless the text is concise. The purpose of a field guide is to facilitate field identification and not provide a treatise on avian life histories. In way of illustration I've counted the words each Australian guide uses to describe the Ruddy Turnstone, *Arenaria interpes,* a bird which occurs throughout Australia. Hindwood and McGill use 60, Cayley 127, Slater 155 and Pizzey 190 words. With one third of the words and no illustrations, Hindwood and McGill's description enables the easy identification of the turnstone in the field.

Don't misunderstand me. Pizzey's book and Slater's two volumes are both useful, and I'm happy to have them on my shelves. But thats just it. They are not field guides. They are on my book shelves, not in my office nor backpocket and field bag. At least in southeastern Australia, that place is



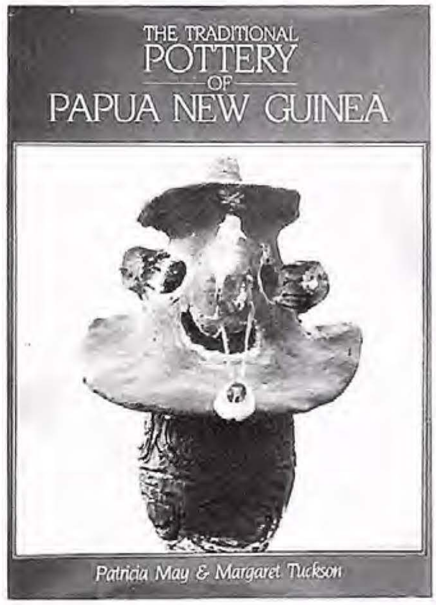
reserved for my well worn copy of Hindwood and McGill. — *Harry Recher, Curator of Vertebrate Ecology, the Australian Museum.*

The Traditional Pottery of Papua New Guinea **by Patricia May & Margaret Tuckson. Bay Books Sydney 1982, 378 pages $99.50.**

It is only in recent years that people studying the rich and diverse cultures of Papua New Guinea have begun to redirect their attention to that country's material culture — to the objects Papua New Guineans make and use to mediate between themselves and the environment. This is a fascinating and complex study, and an important one, since it is often in the distinctive material products of their society that people find the symbols of their cultural identity. It is also a matter of some urgency, as the impact of western technology is increasingly eroding the traditional skills of Papua New Guinea's artists and craftsmen.

The Traditional Pottery of Papua New Guinea is lavishly produced and illustrated and is the first comprehensive survey of a particular technology throughout the country. Until the publication of this book information about Papua New Guinea's various pottery industries was scattered through a number of articles, reports, unpublished manuscripts, diaries and the chapters of various books. The authors have drawn together all these threads (no mean achievement in itself) and added them to the results of their own extensive fieldwork carried out over nearly a decade, and the information stored in museum collections.

Beginning with an introduction and general chapter of clay and tech iques, the book goes onto describe each industry individually. The descriptions concentrate on the technology — the clay source and clay content, preparation, manufacture and firing — supplemented with some information about the indigenous classifications of the pots and their functions, associated mythology, trading links and changes in the industries over time. The introductory chapters describe the general characterisations of potting in Papua New Guinea as well as mapping the distribution of the industries, and the two major techniques of manufacture — coiling and paddle and anvil. They also consider the connections between the distribution of these techniques and the two major distinguishing characteristics — whether the potters in a particular area are male or female, and to which major language group (Austronesian or non-Austronesian) they belong. One of the authors, Margaret Tuckson, is herself an ac-



complished potter, and accounts of the potting techniques are informed with a clear comprehension of their purposes and value.

The wealth of information in the text is paralleled by the riches to be found in the many photographs which illustrate it. Included are photographs of the pots, potters and potting techniques, as well as several spectacular views of the country itself. In many senses this book is worth possessing for the illustrations alone. They are meticulously captioned and all the pots photographed are identified in an appendix.

The relevance of *The Traditional Pottery of Papua New Guinea* to many different fields need hardly be declared. It is of great interest to potters, archaeologists, anthropologists, art historians, museum curators, and many others concerned with Papua New Guinea. It is also important to the Papua New Guineans themselves. In their preface the authors express the hope that the book will "stimulate the interest and the pride of both the established potters and the young people in whose hands lies the fate of the country's ceramic traditions". — *Lissant Bolton, Dept of Anthropology, The Australian Museum.*

Books Received

Evolution of the Flora and Fauna of Arid Australia **by W. R. Barker & P. J. M. Greenslade (eds.)**
The Bush in Bloom **by Kathleen McArthur**
Wildlife in the Suburbs **by Densey Clyne**
The Care of Reptiles and Amphibians in Captivity **by Christopher Mattison.**
Shell Bed to Shell Midden **by Betty Meehan**

Natural pollution monitors

by Michael Tyler

Supernumerary limbs, in this case present in Limnodynastes tasmaniensis, *are common in frogs from some areas of southern Australia but are unknown from the north of the continent. The limbs have a separate nerve supply and are capable of movement.*

These days it is almost impossible to pick up a popular magazine lacking a cartoon about frogs. Modern variations on the old folk-tale of transformed princes, or else legless frogs emerging from restaurants on crutches or in wheelchairs are commonplace. The theme of all of these cartoons is of abnormality and, in an environmental sense, this aspect is an appropriate one.

In the Department of Zoology at the University of Adelaide studies are well underway on the relationship between environmental disturbance by pollution and the incidence of skeletal abnormalities in natural populations of frogs. The overall plan is to determine whether particular pollutants are responsible for recognisable kinds of abnormalities, and whether the examination of these abnormalities in frog populations will provide a simple warning system to the existence of environmental pollution.

Michael Tyler is a Senior Lecturer at the University of Adelaide and an authority on frogs. Apart from the project outlined above, Michael is also working on the evolutionary relationships of Australian frogs and studying the extraordinary Gastric Breeding Frog.

Each year literally thousands of new chemical substances are produced and released upon the market—fertilisers, drugs, cosmetics, insecticides, solvents, plastics, fuel additives and many others. In an environmental sense some are harmless, others are harmful but degrade rapidly, while yet more leave residues that contaminate the atmosphere, soil or water, and may pose some degree of threat to the health of plants or animals.

The pre-release scrutiny that any substance receives is allied to the intimacy of its association with man. A new drug for administration to humans is likely to receive very detailed examination, whereas a drain cleaner may not earn any attention at all.

At least one of the problems of monitoring new substances that will eventually be released into the environment is recognising the relevance (or irrelevance) to environmental issues of the tests that are available. It may fulfil the requirements of a government regulatory body to inject a new insecticide beneath the skin of laboratory white mice, and calculate the highest concentration that the mice can tolerate over the span of perhaps 48 hours. But it is a different matter to establish the highest concentrations in pond water that can be tolerated by aquatic organisms living there and so possibly exposed to that chemical for every day of their lives.

Biologists are primarily concerned with an intriguing aspect of pollution, namely the effect upon non-target species, whereas the human species is the one considered to be most important in the orientation of most monitoring tests.

The likely danger to man of totally new compounds is initially assessed from tests on other organisms including laboratory animals such as the mouse, rat, rabbit, cat and dog. Environmental dangers similarly are assessed from a group of approved aquatic organisms such as mussels, fishes and *Daphnia*. Each is selected for a different reason — mussels primarily because they live in muddy river sediment and tend to accumulate heavy metals continuously, so reaching levels in their tissues far higher than those in the surrounding environment (bioaccumulation). *Daphnia*, water fleas, are small, live in vast numbers and any changes to their reproductive ability can be detected quickly and cheaply. Fishes are used mainly because of their sensitivity to (and inability to survive) low levels of many aquatic contaminants. They too may show decreased breeding ability.

The selection of freshwater monitoring organisms obviously will be

Natural pollution monitors

influenced by several factors, but most of those used will exhibit a change in the abundance or reproductive potential, changes in growth (in algae), incidence of death or else the disturbance to the structure of their descendants.

Experiences in Australia and overseas demonstrate that frog spawn and tadpoles are sensitive to a variety of contaminants at exceptionally low concentrations. By far the greatest attention is devoted to acute (short term) exposures which establish whether an organism will survive or not, and it has been found that with some insecticides death occurs following exposures to concentrations as low as 0.005 parts per million (ppm). Fortunately such extreme sensitivity is rare, but in several countries declines in frog populations over the past 30 years are being attributed to the increased use of insecticides and herbicides.

Details of acute toxicity studies often make depressing reading, and the use of such techniques is deplored by anti-vivisection groups. However it is essential to be conscious of the critical levels of actual or potential contaminants that kill test organisms. Perhaps of greater significance to natural populations of animals are the effects of chronic (long term) exposure at the levels that those contaminants are likely to be encountered in the environment.

Far below the concentrations that kill animals, some pollutants interfere with the processes of natural growth, so producing physical abnormalities. This phenomenon is well demonstrated by Australian frogs.

The value of the frog as a subject in studies of chronic toxicity lies in the fact that it is the highest form of life to lay unprotected eggs in an aquatic environment. The eggs and tadpoles are exposed to all pollutants present in the water in which they live.

What is so significant is that the eggs and tadpoles are undergoing complex cell division and elaborate growth processes during this aquatic life. Some chemicals interfere with those processes sufficiently to alter the shape and form of parts of the body and so produce abnormal frogs. As a result, almost all abnormalities seen in adult frogs can be traced to events that took place while they were tadpoles in water.

The distinction between 'normal' and 'abnormal' often is imprecise because individuals of all species vary in form to some extent. If the variable feature can be quantified, then the normal state is more easily recognised. For example normal frogs have five toes, and so any frog with four or six is clearly abnormal. But when it is necessary to try to express one part as broader or shorter than normal, defining just what constitutes abnormal can be extremely difficult.

A comparison of two frogs of the same species showing reduction in finger length of the left hand. This is an extreme example of an abnormality common in ground-dwelling frogs in parts of the Northern Territory.

All populations of animals include abnormal individuals and this is true of humans as much as frogs. So if there is any possibility of using the incidence of abnormalities in a natural population of frogs as an index of pollution, the first step is to establish the customary ('acceptable') level of abnormality in that species.

This is a real problem. Breeding records for laboratory animals are readily accessible, demonstrating that in laboratory rats the incidence of limb abnormalities is approximately 0.5 per cent. For cattle and pedigree cats and dogs few figures are available. The last thing any stud breeder would admit is the frequency or even existence of abnormality in any of his stock lines. However zoo, veterinary and other sources suggest that grossly abnormal domestic pets can occur at an incidence of up to 6 percent.

In the case of frogs the environment is so disturbed by man that there are now few places left on earth where they live in relatively undisturbed areas. Hence it is difficult to establish just what the customary level of abnormality is in a population not exposed to chemical or other interference. Land clearance, mining wastes, mosquito spraying programmes, application of fertilisers, weed control, and radioactive waste all may have an impact affecting normal growth. Run-off from highways, overzealous spraying of insecticides to

This unusual frog, Limnodynastes dumerili, *found near Gawler, South Australia, was an albino which, after some months in captivity began to develop large patches of black pigment.*

protect golf courses from lawn beetles, indiscriminate use of agricultural chemicals, and the discharging of industrial wastes are all potential inducers of physical abnormality.

Ideal control populations are only obtained from the very few 19th century collections in museums picked up before the advent of pesticide sprays, or samples taken more recently but in remote areas not grossly altered by modern man and where there has been no insecticide or herbicide spraying. In Australia 19th century collection of frog specimens are almost non-existent because naturalists collected the more spectacular marsupials, birds and insects. As a result, Australian studies are based upon early overseas collections and also samples from sites where the influence of man has been minimal. Analysis of these samples reveals that the customary level of abnormality is approximately 0.5—1.2 percent.

Animals which are grossly misshapen are termed monsters. Among frogs, individuals with additional limbs are located from time to time, but minor limb abnormalities occur much more frequently but are not as obvious. These abnormalities include the fusion of two digits to form one broad one, reduction of the length of one or more fingers or toes or the complete limb, and the presence of additional digits. Some of these structurally minor abnormalities are lethal. For example, loss of the shovel-like tubercle on the undersurface of the foot of a burrowing frog could prevent the creature from burrowing beneath the surface of the ground at dusk to avoid the heat of the sun from which normally it would be protected. That such abnormalities are lethal is confirmed by the fact that they are common in some juveniles, but rare in adults, permitting the conclusion that few of these deprived juveniles survive to adult state.

Minor abnormalities can be produced by the exposure of tadpoles to a wide range of aquatic substances, and our studies are further confused by the ability of tadpoles to regenerate an amputed limb or foot. If amputation occurs early in tadpole life when the limb is simply a tiny, dividing bud, the regenerated limb can grow into a perfect form, but the later the limb is damaged in the growth cycle, effects regenerative ability and the replacement can become increasingly abnormal.

Certain insecticides, herbicides, heavy metals, ionising radiation, laser beams and even the aflotoxins produced by fungae can interfere with normal tadpole limb growth, and so produce abnormalities. Although nothing can be deduced from the occasional abnormality encountered during a field survey, there is probably a common cause when the same type of abnormality occurs frequently in a population.

One day it may be possible to suggest the nature of contaminants in an area just from examination of the abnormal frogs. This activity is not manipulation of animals for human benefit, but rather it is of joint interest. The fact of the situation is that abnormal animals exist now. What we lack are sufficient data to exploit this unique environmental monitoring system.

Unfortunately for the good of mankind evidence of severe environmental harm may have to be ignored. For example, in Africa, the poison used to destroy freshwater snails that are hosts to parasites which cause the dreadful disease schistosomiasis also wipes out vast numbers of harmless aquatic organisms as well.

A second example is to be found in Poland where every effort is being made to lift agricultural production. Unfortunately the normal rate of agricultural application of two pesticides used there is 300 times the dose sufficient to destroy tadpoles.

Australian authorities tend to rely for their information upon results of toxicity trials conducted overseas. Obviously needless duplication of tests should be avoided, if only for economic reasons. However, some harmful chemicals are substantially more soluble in the warm waters of northern Australia, than at the temperatures at which overseas tests are conducted. As a result there is a greater potential of damage to other organisms than in colder climates and experience here and overseas suggests that frogs are sensitive organisms that can be useful alternatives to toxicity trials for monitoring environmental damage.

Charming ambassadors of our northern forests

Possums of Australia Part 2 — the north

by John Winter

As any visitor to the northern forests of Australia will know, encountering unusual animals is a matter of course. Probably some of the most pleasant meetings are with the possums and gliders which inhabit these forests. In virtually no other area of Australia will the observer see any larger concentration of possum types.

John Winter, a Senior Zoologist with the Queensland National Parks & Wildlife Service in Townsville, has spent the last ten years investigating the distribution of mammals in Cape York Peninsula and in the rainforests of north Queensland. His special interest is in these charming ambassadors.

The largest concentration of possum types in Australia, with the possible exception of south east Victoria, occurs in the ranges that skirt the Atherton and Evelyn Tablelands in Queensland where cool, upland rain forests stand adjacent to narrow bands of magnificent tall eucalypt forests of flooded gum and mountain stringy bark.

Here, at night, the forest visitor with a spotlight and binoculars may, if lucky, see twelve species of possums and gliders within a few kilometres of each other.

Climate, vegetation, topography and geographical location combine in a narrow strip stretching no more than eighty kilometres from the Lamb Range to Koombooloomba. Standing in one spot in this tiny area it is possible to see seven types of possum. A little patience will be rewarded by the sight of three Ringtails — the Green ringtail, *Pseudocheirus archeri*, the Herbert River Ringtail, *Pseudocheirus herbertensis*, and the Lemuroid Ringtail *Pseudocheirus lemuroides*, a distinct reddish race of the Common Brushtail, *Trichosurus vulpecula*, called the Coppery Brushtail, the boldly marked Striped Possum, *Dactylopsila trivirgata*, the tiny Long-tailed Pygmy Possum, *Cercartetus caudatus*, and the only glider of the rainforest — the Sugar Glider, *Petaurus breviceps*.

Moving less than half a kilometre into the tall, eucalypt forest, another group of possums and gliders are found. Still present are the Sugar Gliders and Common Brushtail in addition to the Common Ringtail *Pseudocheirus peregrinus*, and three types of glider, the spectacular Yellow-bellied or Fluffy Glider *Petaurus australis*, the much more stolid Greater Glider *Petauroides volans* and the tiny, hyperactive Feathertail Glider, *Acrobates pygmaeus*.

To find the twelfth species, the phlegmatic and slightly larger-version of the Sugar Glider, namely the Squirrel Glider *P. norfolcensis*, one has to go two to three kilometres west into the drier and marginally less tall eucalypt forest typified by the forest red gum.

There are five other northern possums that live far removed from the Atherton Uplands area. The two species of Cuscus are found at Coen in northern Cape York Peninsula and from there into the rain forests of the McIlwraith Range or the Iron Range area. Here the Spotted Cuscus, *Phalanger maculatus*, and the Grey Cuscus, *P. orientalis*, can be seen together as well as the Striped Possum and the Sugar Glider. These Cape York rainforests represent a microcosm of the New Guinea forest as these four possums together with many other animals all occur in New Guinea.

Finally, the searcher has to cross the gulf plains at the base of the Gulf of Carpentaria to north western Australia

The smallest rainforest possum in northern Australia is the Long-tailed Pygmy Possum with its body only 10 to 11 centimetres long and a tail about one and a half times as long as the body. Photo H. & J. Beste (NPIAW).

Opposite, the Spotted Cuscus is one of the two species of cuscuses and is recognised by its very small rounded ears, the pinkish yellow colour of the skin exposed on the muzzle, feet and tail and a rim of pink skin circling the eyes. Photo M. McNaughton (NPIAW).

to find the remaining three northern possums. The Rock Ringtail, *Pseudocheirus dahli,* lives in the sandstone escarpments from the Queensland border region, through Arnhem Land to the Kimberley region of northern West Australia where the Scaly-tailed Possum, *Wyulda squamicaudata,* is found. Both are unique in this region which is also the home of the Northern Brushtail, *Trichosurus arnhemensis.*

The three Atherton Uplands ringtails are quite distinct from the Common Ringtail Possum. While the Green Ringtail is closely related to the New Guinea Eastern Ringtail, *P. corrinae* the Herbert River Ringtail and the Lemuroid Ringtail have no closely related forms.

Most distinct of these three in anatomy and habits, is the Lemuroid Ringtail. It has a pug-like face resulting from a shorter, less pointed nose and very large eyes set more to the front. These facial features with a general body appearance, which is rounded and fluffy with a bushy tail, give it a superficial resemblance to a Malagasian lemur which was common in European zoos at the time when the Swedish zoologist, Robert Collett in 1884 gave it the specific name *lemuroides.* At night this ringtail can easily be recognised by its dazzling yellow eyeshine which is reflected from a spotlight like that of the Great Glider of the open forests.

The Lemuroid Ringtail is able to leap one to two metres through the canopy with its legs spreadeagled, artfully grasping the twigs as it lands. It is the only one of the larger possums to make such leaps as the other species limit their jumps between main branches. The Lemuroid Ringtail even has the rudiment of a skin flap each side of the body which gives rise to its original generic name *Hemibelideus,* meaning half glider and of which it is the only member.

Lemuroid Ringtails are frequently seen in families of three — a male, female and a young one. The family remains together throughout the day, making it the most gregarious of the ringtails. The animals have a musky smell which is quite discernable at night although it is difficult to locate the possum by its smell alone. Scent may well be their major sense of communication as the Lemuroid Ringtails are in the main silent, giving only the occasional quiet hiss.

The Green Ringtail is a very different animal from the Lemuroid Ringtail in both looks and habits. The face is short and pointed, the ears small, the tail has a thick base that tapers to the tip with the fur lying flat against the skin and a dumpy, round body accentuated by its habit of sitting hunched with its tail between its legs and tightly curled in a ring under its nose. In certain lights its fur takes on a distinct, greenish tinge from the fine banding of black, yellow and white on the individual hairs. It is probably the most subtle and beautifully coloured of all the Australian possums, having tinges of green in its soft, thick fur, white patches under the eyes and ears and two silvery, golden stripes down its back.

Only observed in 1938, eighty-eight years after the discovery of the Spotted Cuscus, the Grey Cuscus is confined to rainforest and eats both leaves and the white flesh of rainforest nuts. Photo courtesy of the Queensland National Parks & Wildlife Service.

When disturbed at night, the Green Ringtail normally takes up the hunched sitting position on a branch and will sit motionless for hours. This position is probably its means of escaping detection and is possibly derived from its unusual habit of spending the day sitting on a branch rather than sheltering in a den. Despite this stolid behaviour, the possum is able to run and climb rapidly.

Living in the vine thickets and understorey of rainforests, the Green Ringtail frequents the canopy of Strangler Fig Trees. Probably the most solitary of the Ringtails, this possum is only rarely seen in pairs, and then it is usually a mother and her young. The male and female come together for only a brief period at mating time and do not establish a pair-bond. Usually only one young is reared. Like the other possums, it has scent glands opening into the cloaca, but to humans it is one of the least smelly of the larger possums. Only young Green Ringtails are heard to make a sound, a weak tsk-tsk-tsk when separated from their mother.

Most striking of the possums is the Herbert River Ringtail with its bold colouring of dark brown, almost black body fur, pure white belly, frequently with the white extending as bands around the upper part of the arm and a white tail tip. Seen at close quarters, however, the Herbert River Ringtail has rather an ugly face with a prominent 'Roman' nose and it lacks the appeal of the Ringtail's short face and large eyes, or the Green Ringtail's very delicate colouring. The amount of white on the Herbert River Ringtail can vary from nearly all white in rare individuals to almost none in many others. Usually, however, there is at least a white spot on the chest and a white tip to the tail. Such sombre individuals can be mistaken for Lemuroid Ringtails but the tapering tail with the fur closely adpressed is the surest distinguishing feature.

Although generally seen alone, the Herbert River Ringtail forms a loose pair for two to three weeks prior to mating when the male follows the female throughout the night, but does not share her den. Two young are raised and emerge from the pouch towards the end of September. After leaving the pouch, young venture out into the forest on their own, although they will continue to share their mother's den during the day. Juveniles weighing only 300g, which is a third of their mother's weight, may be found sitting quite still in low foliage, and when disturbed make rather ineffectual leaps in their attempts to escape.

The young are easily recognised because of their distinct colouring which is a pale buff being slightly paler in the areas which will become white in the adult. This juvenile colouring persists for nine to twelve months and it is the tail which first changes to the typical adult colouring of black with a white tip.

A distinct race retaining its juvenile colouring throughout its life, this possum is found in the hills behind Mossman and north of the Daintree River. Their usual daytime den is a hollow tree or epiphyte clump although they have been known to use a constructed nest like that of the Common Ringtail.

Similar in size and in other respects, the three ringtails use different parts of the rainforest, minimising competition with one another.

Of the rainforest possums, the Striped Possum is the most venturesome. It moves furthest into adjacent types of forest and it is quite frequently found in open eucalypt forest several kilometres from rainforest, although it is most readily seen at the forest edge.

A very different animal from the ringtails, the Striped Possum has a long, slender body which is accentuated by broad, longitudinal black and white stripes, a long bushy non-prehensile tail and a disproportionally large head. They have two long, sharp, lower incisors which lie almost flat in the jaw and two upper incisors, worn down to blunt pegs in older animals, presumably from using them to rip open dead wood in their search for insects. The fourth finger of the hand is almost twice as long as the other fingers and is used to probe excavations in the spongy, rotten wood of standing dead tree trunks in search of the fat, juicy larvae of the longicorn beetles and under the bark of dead branches for various insects.

In the forest at night the sound of wood being ripped apart in a possum's quest for food may be the first indication of its presence. Often when the possum becomes totally engrossed in this activity and is apparently oblivious to its surroundings, it can easily be approached. Other items of its diet are ants, the nests of native bees and bananas. The Striped Possum is an agile climber and regularly makes leaps of one to two metres. It prefers a landing with a firm footing, but like the Lemuroid Ringtail, will land on foliage.

A hole in a tree is used as a den and it is lined with leaves, carried there in bundles tightly wrapped in the tail. In contrast to the ringtails, the Striped Possum is much more vocal, giving a variety of harsh, growling calls changing in pitch as the animal inhales and exhales. Generally solitary, they appear to come together for only a brief courtship period and mating after which one young is produced.

The Striped Possum has a strong, musky smell that can be detected in the forest. When engrossed in the noisy process of searching for food in dead wood, the possum could be vulnerable to predation from owls. Perhaps the strong smell makes them distasteful and the striking colour pattern readily identifies them as such.

The strong smell, deposited on branches by a rubbing motion of the cloaca, may also communicate an individual's presence to other Striped Possums in the forest. This may be particularly important for an animal that naturally occurs in low numbers thinly scattered through the forest.

Smallest of the rainforest possums in northern Australia is the Long-tailed Pygmy Possum, with its body only 10 to 11 centimetres long and a tail about one and a half times as long as the body. It is a secretive animal, shy of the spotlight and is usually detected as a flash of movement on a branch. Being an insect and nectar feeder, it is most easily found

Smallest of the rainforest possums in northern Australia is the Long-tailed Pygmy Possum (right), with its body only 10 to 11 centimetres long and tail about one and a half times as long as the body. Photo R. Whitford (NPIAW).

The Squirrel Glider (above), lives in eucalypt forest and is one of Australia's most beautiful gliding possums. A voracious insectivore the Squirrel Glider also spends considerable time licking up flower nectar and tree sap or kino. They are very social creatures, often living in family groups of five to six individuals. Photo E. Beaton (NPIAW).

when it is probing for nectar deep inside the flowers of the Bumpy Satin Ash, *Syzigiium cormiflora,* which grow on the trunk and entice the Pygmy Possum close to the ground.

The large, black patch round the eye, the crinkled ears, the furred base to the tail and the typical possum hind foot with its two grooming toes and opposable thumb, distinguish it from any similarly sized native rats. The tiny pouch contains four teats and four young may be raised at a time. In Australia the Long-tailed Pygmy Possum is confined to the rainforest but in New Guinea where it also occurs, it lives in the tall grass of abandoned gardens and builds small ball-like nests above the ground.

In the forests of the Cape York Peninsula a casual observer may be startled to see a round, furry face with large, red-rimmed eyes staring through the foliage. This belongs to the Spotted Cuscus which occurs mainly in rainforests from sea level to mountain summits that reach an altitude of 820 metres.

It does not use a den or nest but is reputed to build a small sleeping platform of leaves by drawing twigs in under itself and even hides by pulling leaves between itself and an observer. Although it may feed during the day it is mainly nocturnal.

The two species of cuscuses (Grey and Spotted) are confined to the northern part of Cape York Peninsula, north of Coen and are also found in New Guinea. They differ greatly from one another both in looks and habits. The Spotted Cuscus is the more brash of the two, being heavier and active during the day, enabling it to be readily seen, whereas the delicately built Grey Cuscus is a retiring animal.

Cuscuses differ from other possums by having prominent canine teeth which suggest a carnivorous diet. Both have completely naked tails over the last two-thirds of their length, a feature shared only by the Scaly-tailed Possum. The under surface of the tail is covered with rasp-like papillae enhancing its gripping ability on the branches of trees.

The Grey Cuscus is a more nocturnal animal than the spotted species, and does not spend the day in the foliage. It is easily distinguished from the Spotted Cuscus, by its prominent ears, dark stripe down the middle of its uniform greyish-brown forehead and back, and by the colour of its skin which is grey. The Grey Cuscus is predominantly a vegetarian and eats both leaves and the white flesh of rainforest nuts.

The Australian subspecies of the Spotted Cuscus was described by Gould in 1850 whereas the Grey Cuscus was not observed until 1938, eighty-eight years later, and eventually catalogued in 1945. Anthropologist Donald Thomson, while working and living with the Aborigines of the McIlwraith and Iron Range areas in the late 1920's, failed to mention the Grey Cuscus. He was aware of the Spotted Cuscus *Ampoyiu* but was not aware of the Grey species which the Lockhart Aborigines call *Too-ili.*

Three features readily distinguish the Spotted Cuscus. The very small rounded ears which barely protrude beyond the fur and give the animal a seal-like appearance, the pinkish yellow colour of the skin exposed on the muzzle, feet and tail and a rim of pink skin circling the eyes which accentuates its pop-eyed appearance.

The fur colour varies considerably. Generally the males have a greyish-brown coat with a scattering of large, pale, irregular spots while the females have a uniform grey back, sometimes with a large pale patch on the rump, and cream coloured belly fur.

Spotted Cuscusses are solitary animals except for brief courtship periods and are mainly vegetarian despite their enlarged canine teeth. The cuscus is not a hunter in the sense of pursuing a mobile prey but it sometimes feeds on bird's eggs and small animals. It is a ponderous climber having an exceedingly strong grip with its feet and tail.

Both species can behave aggressively when captured and can put on a 'good show' of swatting with the front paws, accompanied by loud and varied screeches and grunts. In the threat position the paws are held low in front of the body rather than in the usual possum manner of high and to the side.

The Spotted Cuscus is able to use a much wider range of habitats than the Grey Cuscus as it is capable of living in thin riverine strips of forest and in mangroves, whereas the Grey Cuscus is mostly confined to larger tracts of rainforest. As a result the Spotted Cuscus is spread through Cape York Peninsular as far south as Aurukun. The Grey Cuscus restricts itself to the McIlwraith and Iron Range areas and extends for short distances along narrow riverine strips of forest.

North western Australia is the habitat for two ground dwelling possums, the Rock Ringtail and Scaly-tailed Possum. Being arboreal feeders by night and sheltering by day in rock piles and caves the first indication of their presence may be rustling in dry grass as they head back to their retreat.

The Rock Ringtail is a light grey colour having a dark stripe down the midline of its back and a short tail. The Rock Ringtail eats both leaves and fruit and is mostly seen alone although it is sometimes acccompanied by a young one.

The Scaly-tailed Possum is also light grey with a faint dorsal stripe and can be easily identified by its tail, the fur thinning out to a naked scaly tail for three quarters of its length. A member of the same family as the brushtails and cuscuses, the Scaly-tailed Possum's distinct features place it in a genus of its own.

VICTIMS OF RAINFOREST LOGGING

While the long-term effects of selective logging on rainforest possums in Queensland is not known, biologists have been able to study the response of three ringtails — the Green, Herbert River and Lemuroid Ringtails — to logging operations. All three possums vary in population numbers and scientists believe one possible cause for this may be their response to rainforest disturbance caused by man.

The Green Ringtail seems to be the least affected by partial logging and clearing operations that leave only small fragments of virgin forest. However, this ringtail is drastically affected by clear-felling. It probably survives because it can live in a tangled understorey of logged forests without needing a den. Another advantage is that its diet includes species, particularly fig trees, which are not sought by loggers.

Both the Herbert River Ringtail and Lemuroid Ringtail on the other hand, are noticeably affected by partial logging. Canopy-living Lemuroid Ringtails are severely reduced in selective logging operations, which involve the removal of 50 percent of the canopy. Many of the prime timber species are its favoured feeding trees and of all the rainforest possums it is the most reluctant to come down onto the ground to escape.

In one study of remnant patches of rainforest left after selective logging in the Millaa Millaa district, the Lemuroid Ringtail had vanished from seven of the eleven study sites and was rapidly disappearing from the remaining patches despite these being up to 74 hectares in size.

Similarly, there is a noticeable drop in Herbert River Ringtail numbers following selective logging, although this possum seems better able to cope with rainforest fragmentation. The diet and home of the Herbert River Ringtail include many of the trees used by our timber industry but it is less of a canopy-dweller than the Lemuroid Ringtail and more inclined to come to the ground and escape.

Although the general response of possums to rainforest logging varies according to the species involved, biologists' attention centres on the fruit-eating animals as the prognosis for the survival of the leaf-eating ones is a lot better.

The Green Ringtail (top left), Lemuroid Ringtail (top right) and Herbert River Ringtail (right), are all affected to a greater or lesser degree by rainforest logging. Photos, Y. Dymock, Queensland Museum and H. & J. Beste, respectively.

The solitary Scaly-tailed Possum is vegetarian and raises one young at a time.

The Northern Brushtail, which weighs a maximum of 1.85 kilograms, was for many years considered a subspecies of the larger Common Brushtail until it was identified as an individual species in 1977. Its smaller size and scrawny tail are characteristic of the Cape York Peninsula Brushtail which is regarded as the northern representative of the Common Brushtail.

Both the Common Brushtail and the Common Ringtail occur in the open forest to the northern tip of Cape York Peninsula and both are widely dispersed through Australia. South of Rockhampton, the Common Brushtail is excluded from the rainforest by the Mountain Brushtail, *Trichosurus caninus,* except in Tasmania where the Mountain Brushtail does not occur.

To the north, the Common Brushtail only occurs in upland rainforest near Mackay and on the Atherton uplands, where it is a heavier and redder animal than the typical grey form of the adjacent open forest. At present biologists believe the brushtail is an open forest possum which has adapted in only a limited way to the northern rainforests.

The Common Ringtail, on the other hand, occurs in both open forest and rainforest as far north as Paluma, just northwest of Townsville. At this point it is displaced from the rainforest by the three endemic species of the Atherton Uplands. Like the brushtail it is not found in the lowland rainforest and does not occur in the rainforest anywhere north of the range of the upland ringtails.

All five northern gliders are typically open forest animals having wide ranges beyond the limits of northern Australia. The most widespread is the Sugar Glider which extends right across northern Australia and down eastern Australia to Tasmania. It is also the only glider to be found deep inside rainforests throughout northern Australia. The Sugar Glider is mainly an insect, blossom and sap feeder, while the brushtail and ringtail are predominantly leaf eaters.

The Feathertail Glider occurs in open forest to the tip of Cape York Peninsula, but because of its small size is rarely seen.

The three remaining gliders reach their northern limit on, or just to the south of Mt Windsor Tableland which is also the limit of the tall open eucalypt, or wet sclerophyll forest, that is extensive in south-eastern Australia. The most spectacular of these three gliders in both appearance and habit is the Yellow-bellied Glider. Restricted to the very narrow band of tall open forest on the western edge of the rainforest, this possum taps mountain stringybark trunks for their sap and can easily be found at night because of its loud shrieking gurgling cries.

Biologists believe the northern Australian possums represent three distinct historical lines:

1. relicts of the old and formerly extensive Australian rainforest, represented by the Atherton upland ringtails;

2. New Guinea rainforest species, represented by the Striped Possum and the cuscuses.

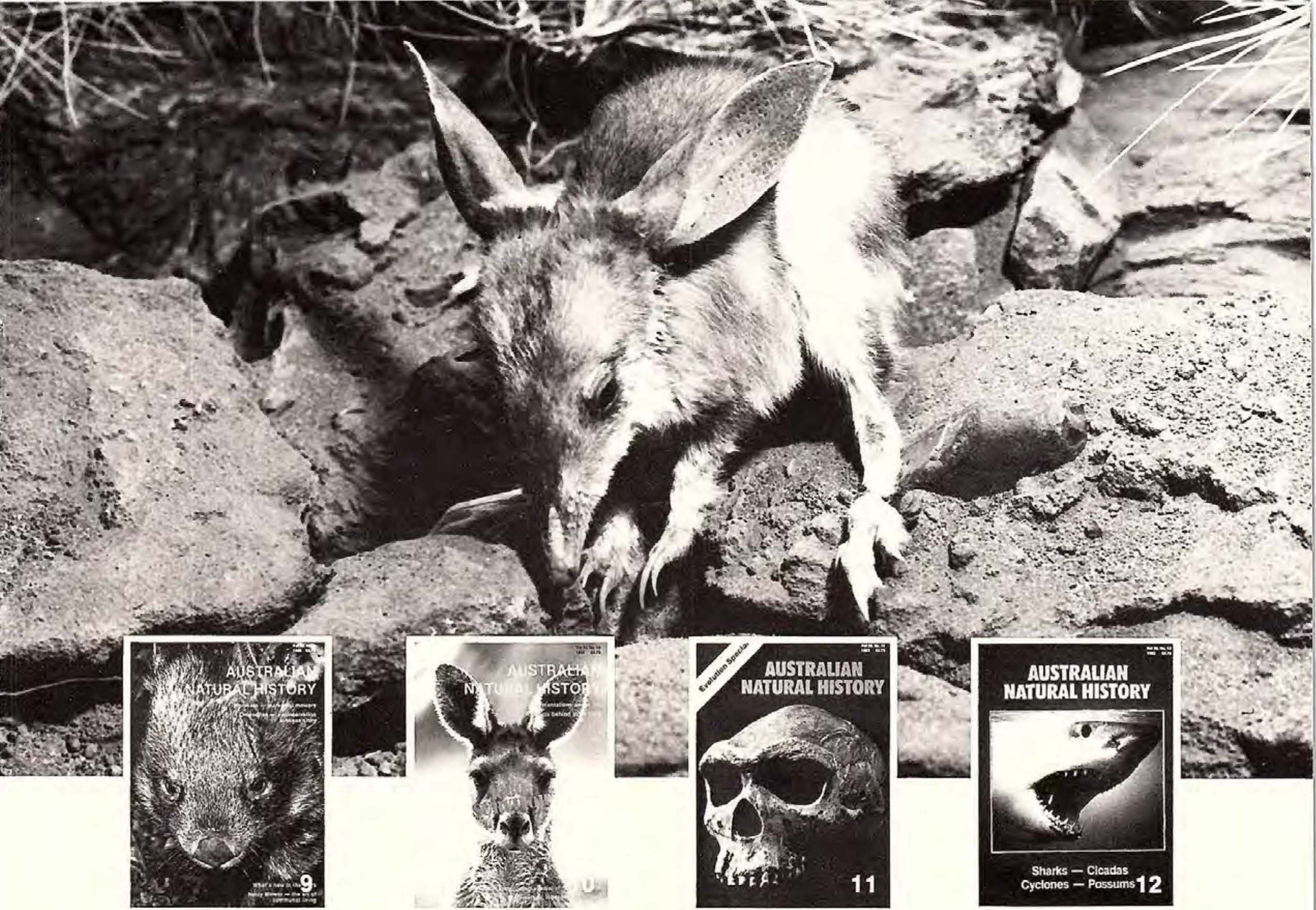
3. open forest Australian species which may have evolved to survive in open forest conditions in south-eastern Australia and subsequently spread widely. In the case of the Sugar Glider, Common Brushtail and Ringtail, all three re-entered the rainforest and lived alongside the relict species. The rock-dwelling possums are specialised representatives of this latter group.

One important exception to this theory is the enigmatic distribution of the Long-tailed Pygmy Possum as its range does not fit neatly into any of the above explanations. Because it occurs in both Australia and New Guinea it is not a relict population nor a recent New Guinea immigrant as it is absent on northern Cape York Peninsula and in lowland New Guinea. The Long-tailed Pygmy Possum is also not an open forest species which has re-entered the rainforest because it only occurs in Australia. The Australian tree kangaroos are also difficult to place.

These perplexing puzzles will keep biologists working for quite a while yet before they will be able to confidently answer questions on our native fauna's origins and diversity.

The Common Striped Possum (left), mainly eats insects, including wood-boring grubs, which it locates by listening for the sound of the grubs boring their way through tree limbs. It then rips away the overlying wood with its teeth and uses its long tongue and specially elongated fourth finger to extract the delicate morsel. Photo R. & D. Keller (NPIAW).

One of the five northern gliders, the Greater Glider (above), is an open forest animal which ranges over wide areas of Australia. Photo G. B. Baker (NPIAW).



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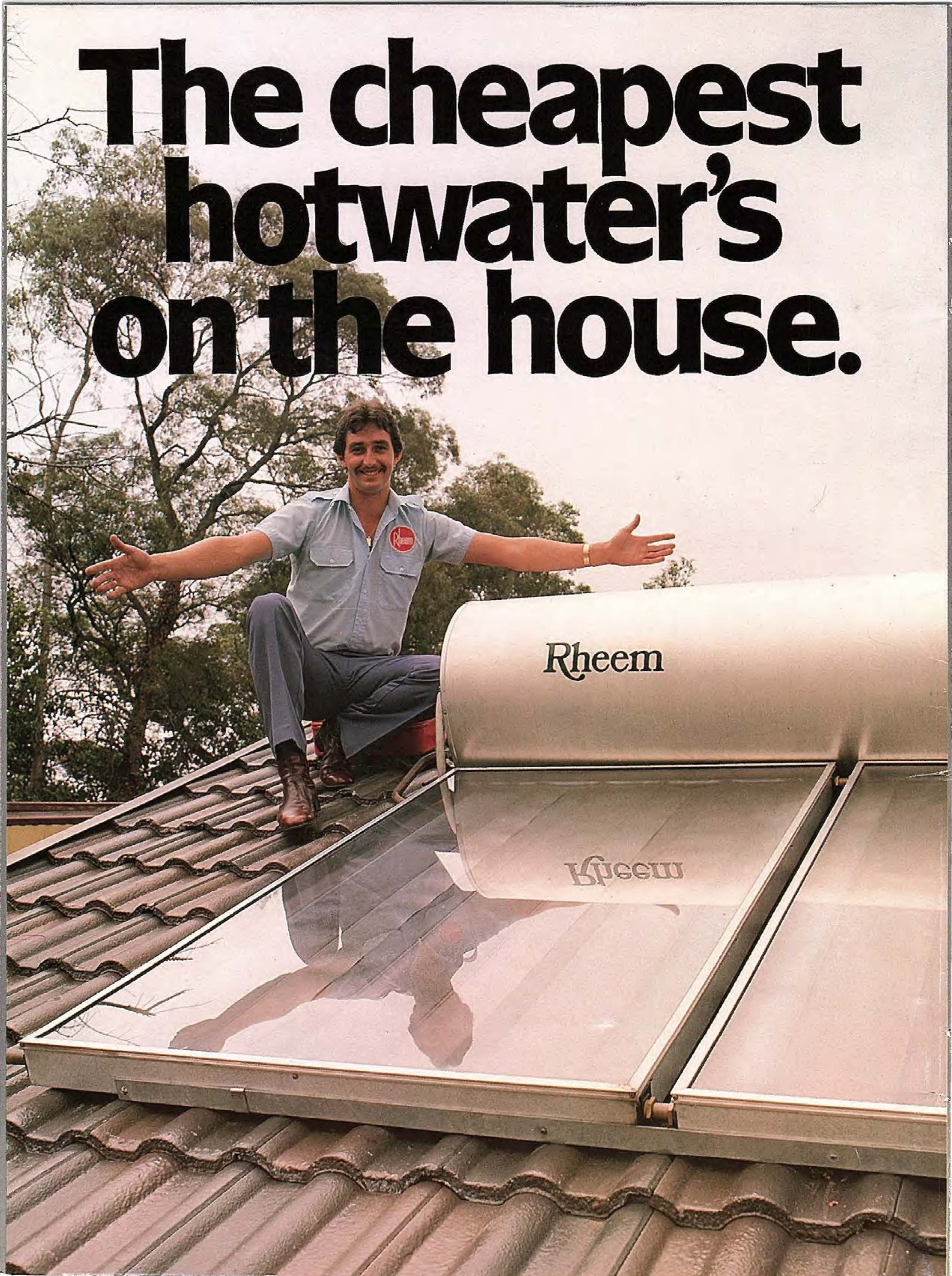
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