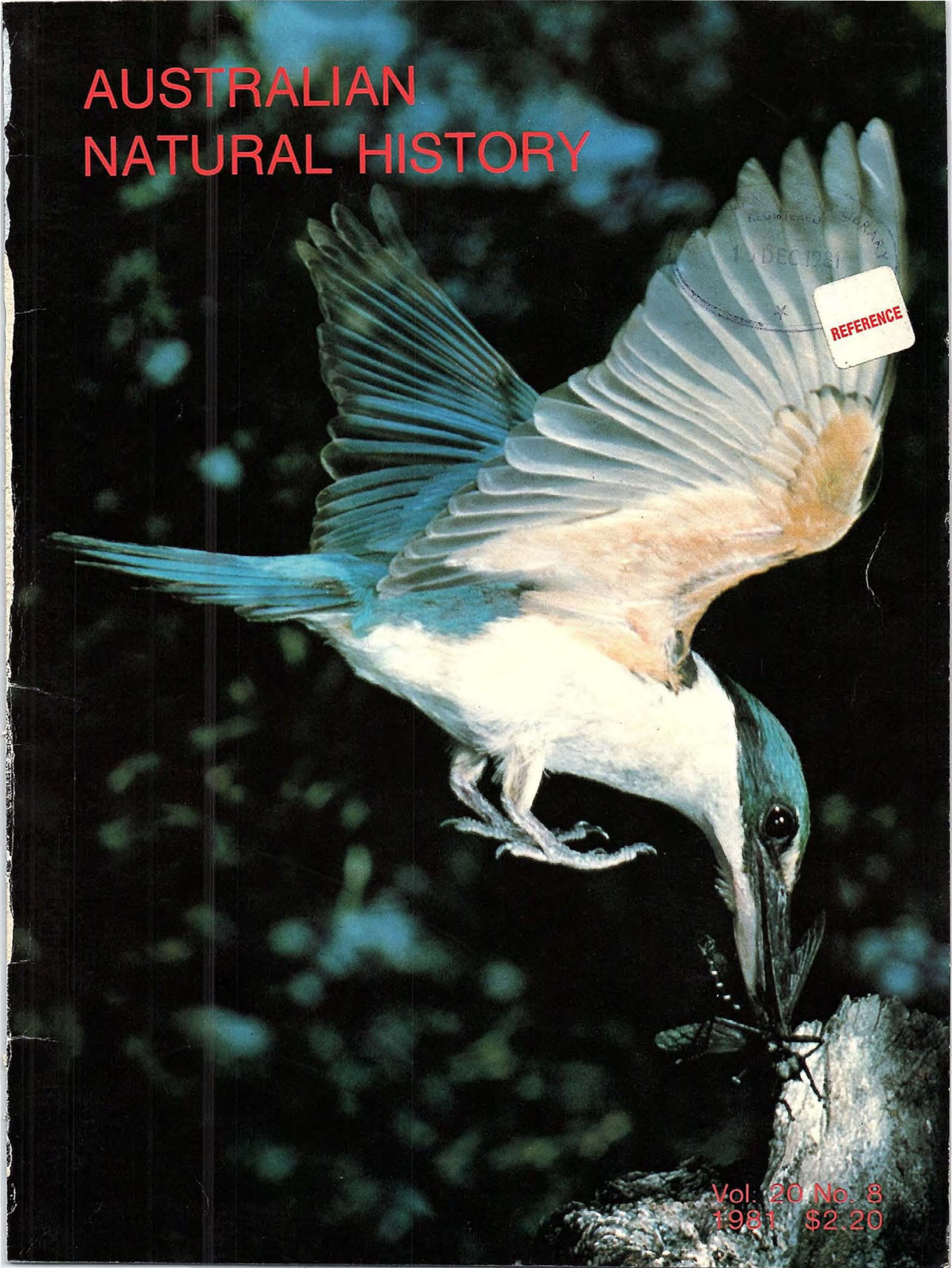
AUSTRALIAN NATURAL HISTORY



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AUSTRALIAN NATURAL HISTORY

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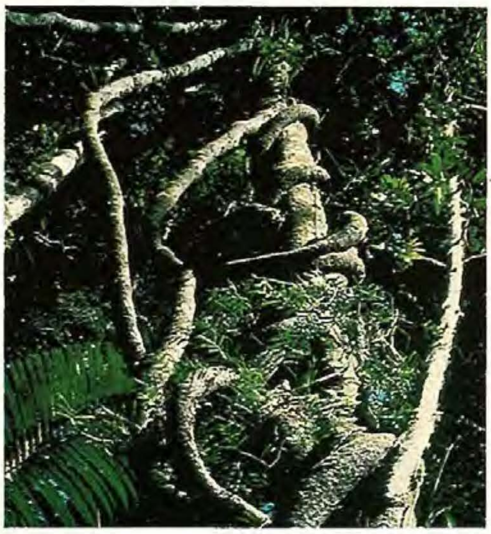

Tangled Water Vines, *Cissus sp*, entwine understorey trees on a tributary of Terania Creek. Photo David Milledge.

Female Sydney Funnel Web, *Atrax robustus*, restricted to the central coast and mountains. Photo Gregory Millen.

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The editors welcome articles or photographs in any field of natural history.

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Natural forest in the Eden district before the start of a woodchip operation. Photo Harry Recher.

Above, 'brown haze' can get especially bad over Sydney during the winter months. Photo Bob Crombie.

Readers of *Australian Natural History* have always been a loyal breed, continually supporting the magazine and Australia's oldest and largest museum. Therefore, as 1981 draws to a close, it is fitting to reflect on the history of the magazine in this its 60th year.

Australian Natural History was born on April 1921, when for the princely sum of one shilling people could buy, for the first time, a regular magazine devoted to Australia's natural history. Published by the Australian Museum, the magazine, originally entitled *The Australian Museum Magazine*, appeared three times a year until 1923, when it became a quarterly.

Intended primarily for the general public the magazine provided readers with some basic knowledge of Australia's environment and the many living things in it as well as an insight into the work undertaken by the Museum's scientists.

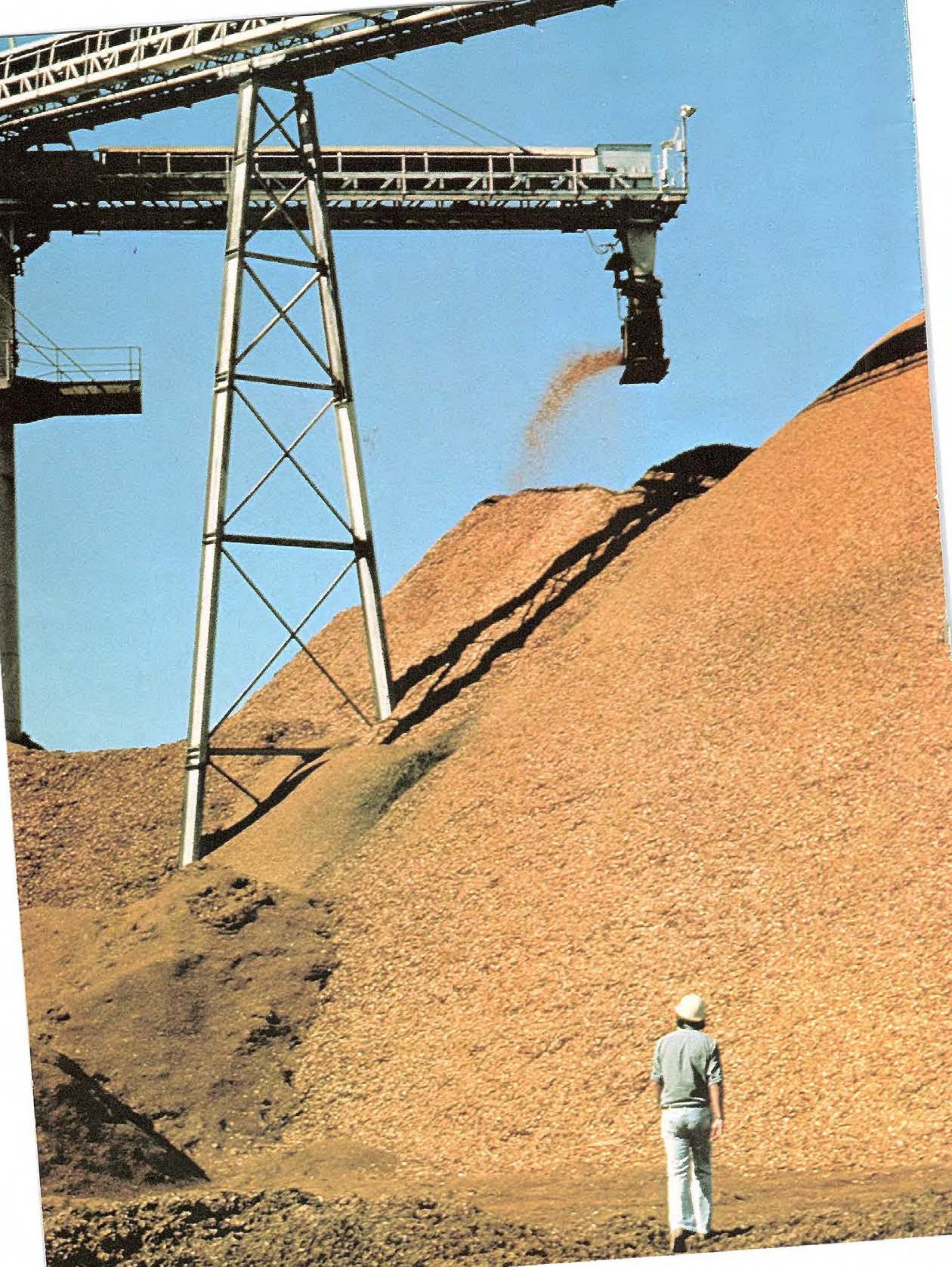
The first editor was the then Director of the Museum, Dr C. Anderson, and in his opening editorial he set down the aims of the magazine and the subject areas it would cover. "The haunts, habits and life-histories of the common animals of our bush, ponds, and seashore will be described . . . we shall endeavour to picture . . . the every-day life of animals, their inter-relations, their struggles for existence, and their place in the whole scheme of nature."

Within a few weeks of release, the first issue of the magazine sold out. The launching had been a success and the completely unexpected had occurred. As a result the second issue was released with double the print-run to satisfy the demand.

By the end of the 1920s a substantial subsidy was needed to maintain publication. The magazine continued to grow and in 1962 its name changed to *Australian Natural History*.

Over the past 60 years the magazine has been a universally accepted authority of Australia's diverse natural history. A tradition has been set. During the next 60 years readers will continue to benefit from the change and development needed to maintain the authoritative nature of the magazine and the Australian Museum.

Roland Hughes
Editor

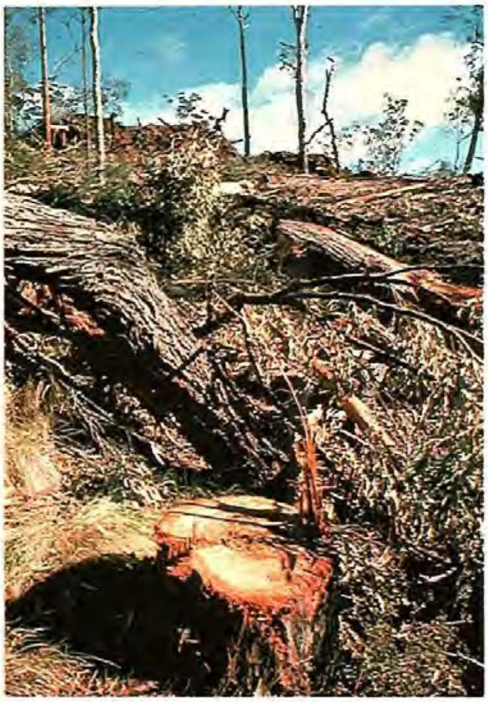


WOODCHIPS OR WILDLIFE?

With Australia's woodchip industry in full swing in Tasmania, New South Wales and Western Australia and having recently begun on a trial basis in East Gippsland, the time has come for a full assessment of forest management methods. Only after full appraisal of forestry procedures will scientists and the public be certain that all the essential parts of the forest ecosystem will survive even the most intensive management practices.

The Eden woodchip operation in particular has come under examination by a joint team of ecologists from the Australian Museum, the NSW Forestry Commission and the NSW National Parks and Wildlife Service. Four of these scientists, Harry Recher, Curator of Vertebrate Ecology at the Australian Museum, Wyn Rohan-Jones, Wildlife Ecologist with the NSW Forestry Commission, and Peter Smith and Daniel Lunney, Research Officers at the National Parks and Wildlife Service, have together produced this important article providing information leading to an understanding of the forest ecosystem and the effect of woodchipping.

by H. F. Recher, D. Lunney, P. Smith and W. Rohan-Jones



Above, debris remaining after logging includes the heads of trees and any section of a cut log which may be twisted, split or hollow. Photo Daniel Lunney.

Opposite, a woodchip mill in operation in the Eden district. Photo Harry Recher.

Hot, dry and flat, Australia is not a forested land. Two hundred years ago, when England took Australia as its own, forests covered 15 per cent of the continent which compared with other continents was a very small area. Moreover, in the brief interlude between Captain Cook and Malcolm Fraser, clearing for agriculture and the spread of human settlement reduced the area of Australia's forest by more than half. Despite this, the forests have been less severely affected by Europeans than the more extensive but drier lands of the interior. There have been few extinctions and large areas of native forest retain their original wildlife.

In today's Australia, forests are being used in ways which could not have been conceived of by an earlier generation. Some forests are being reserved as national parks while others are being harvested more intensively than ever. Land use planning in Australia is not yet well developed or co-ordinated and there is mounting concern that some management practices may not be as kind in the future as they have been in the past. Forests have become the environmental issue of the 1980s.

The 1970s saw the growth of woodchip industries in Tasmania, New South Wales and Western Australia and the replacement of large areas of native forest with plantations of exotic pines. These events coincided with the growth of Australia's environmental consciousness and led to intense and often bitter confrontations between foresters and the timber industry on one side, and environmentalists on the other.

There are many reasons for the intensity of this confrontation, but whatever the causes, insufficient information about the ways that management—whether it is prescribed burning, logging or reservation as a park—affects the forest, has been an important factor. It is responsible in part for the continuing failure of Australians to resolve their differences and work together in the management and conservation of the nation's forests.

Our task as ecologists has been to provide the information and understanding for one part of the forest ecosystem and for one industry; wildlife and the Eden woodchip operation.

The Eden woodchip industry began in 1968 when New South Wales agreed to provide Harris-Daishowa Pty Ltd with 500,000 tonnes of wood each year from the forests in the southeastern corner of the State. A mill was built at Eden and logging commenced in 1969. The history of logging in the southeast dates to the 1840's when the towns of Eden and Bega were settled. For more than a century the region was a source of sawlogs and railway sleepers, but by 1967 economic supplies of sawlogs were very limited. Long years of selective logging which always took the best trees and frequent wildfires had taken their toll. Although extensive, the region's forests were not considered an important timber resource and earlier proposals by the Forestry Commission to expand the area of State Forest had been deferred by the Government.

National park compromise

Much of the area was vacant Crown Land, and, in addition to the proposal by Harris-Daishowa Pty Ltd to establish a woodchip industry, it was suggested by the National Parks Association and supported by the Scientific Committee on Parks and Reserves (which reported to the Minister for Lands) that nearly all the vacant Crown Land (250,000) acres should be dedicated as national park. This was clearly incompatible with the establishment of an export woodchip industry and in the end a compromise was reached between the National Parks Service and the Forestry Commission. Some areas of existing State Forest were revoked to create the Ben Boyd National Park on the coast south of Eden and four parks, Mt Imlay, Nungatta, Nalbaugh and Egan Peaks, were established on the vacant Crown Land west of the Pacific Highway. The remaining land was then dedicated as State Forest.

The reason for these compromises has to be seen in the light of the economic and political climate of the day. In 1967, Eden was

remote, the population stagnant, and opportunities for employment limited. The proposal put forward by Harris-Daishowa provided the government with a means by which the district's economy could be stimulated. The woodchip industry meant growth, jobs and improved social conditions. It also meant a changed forest.

A woodchip operation differs from the kinds of logging we normally associate with timber harvesting. The objective is to produce pulp for the manufacture of paper. The trees which are harvested are not sawn into lengths, but are processed into 'chips', pieces of wood about the size of a fifty cent piece. For this reason, the trees do not need to be tall or straight or even particularly sound. Crooked or hollow, they are all useful. Only trees which are too small (less than 8cm in diameter at breast height) or species, such as Woollybutt, *Eucalyptus longifolia* and Rough-barked Apple, *Angophora floribunda,* with very dark wood containing large amounts of gum are unsuitable as woodchips.

Pulpwood logging is effectively clear-felling; most of the trees are cut. However, the intensity of logging does differ considerably from place to place. In the forests near Bega where Woollybutt is abundant and near Eden where there are extensive stands of young trees which grew after wildfires in 1952 large numbers of trees may be left standing after logging. In addition, logging is excluded from narrow reserves along water courses and on land which is too steep or rocky.

There is also a policy to retain young trees, which are otherwise suitable for harvesting as woodchips, if these are judged capable of growing into sawlogs.

During logging, trees which are useful as sawn timber ('sawlogs') are kept apart and not used for pulp. For this reason, foresters refer to the Eden operation as 'integrated logging' meaning the simultaneous harvest of sawlogs and pulpwood. Whether it is called pulpwood logging, integrated logging or clear-felling is unimportant: what matters is that the advent of the industry dramatically changed the way in which the forests of southeastern New South Wales were managed. Timber harvesting became much more intensive and affected a large area of forest.

Within the area affected by the woodchip industry there is nearly 500,000ha of forest. Eighty per cent of this belongs to the Crown. Of the Crown land, about twenty per cent is reserved as national park or nature reserve. The Forestry Commission estimates that nearly a quarter of the remainder will not be logged because the land is too steep or rocky. However, 12,000ha of native forest has been cleared and replaced by pine plantations in an operation which does not depend on the woodchip industry. A further 4,000ha of native forest has been scheduled for the establishment of a pine plantation. The remaining forest is allowed to regenerate and, under existing plans, will be logged again in 40 to 50 years.

The effect of fires on forest, opposite, can be especially devastating on ridges. Forest ridges are particularly susceptible to hot burns losing all their ground cover and canopy. Despite the charred landscape individual animal species will react differently. Frequency and intensity of fires are the two key factors determining whether various animal populations will recolonise. Steep-sided, wet gulleys, lower right, left by the loggers, are rarely effected by fires. Photos Daniel Lunney.

Logging in progress—the loading of selected logs onto the trucks occurs at 'log dumps' which are stationed at various intervals along the tracks being used in the operation. Photo Daniel Lunney.

Logging began in the East Boyd and Nadgee State Forests and almost immediately the industry was embroiled in controversy. About 4,000ha of forest are logged each year and for the first few years operations tended to be concentrated into a few major fronts. Concern was expressed at the size of the areas being clear-felled and by problems with erosion. There was also considerable dissatisfaction with the compromise reached over national parks. With the exception of Ben Boyd, the new parks were small (the largest is only 4,000ha) and centred on steep terrain.

Many environmentalists questioned the ability of the forest to regenerate after clear-felling. The forests are regenerated mainly by natural means; seeds retained on the heads of fallen trees (only the trunk is used) and sprouts which develop from the cut stumps of some species of eucalypts are the source of the new forest. Initially, areas which have been clear-felled look quite barren. Not only are most of the trees cut, but wherever there has been heavy machinery, the ground is torn up and the soil exposed. When viewed across the large expanses of the first areas to be logged, the effect was particularly devastating. Conservationists were convinced that the forest was doomed.

Government inquiry

The extension of export woodchip industries to Tasmania and Western Australia coupled with proposals for similar operations in Victoria and Queensland intensified public concern for the future of Australia's forests. In response, the Senate Standing Committee on Science and Environment held an inquiry into woodchip operations throughout Australia and in 1977 issued a report entitled *Woodchips and the Environment*.

At about the same time, the government of New South Wales enquired into the Eden woodchip operation with particular emphasis on the coastal forests near Bega. Both inquiries concluded that the industry should continue, but drew attention to the many environmental problems created by broad area pulpwood logging.

The controversy surrounding the Eden industry has been beneficial. Additional lands have been reserved as national parks. Attention was focused on problems and discussed openly by all parties. Foresters responded with the adoption of new management procedures to minimize the impact of integrated logging. Procedures which have been successful in controlling erosion, helping to protect scenic values and ensuring that the forest did grow again. Research was initiated into the environmental effects of pulpwood logging and results of that research are used to further refine management plans.

Our own research is typical of the wider effort. Biologists from the Australian Museum, Forestry Commission and National Parks and Wildlife Service work together in an effort to understand the ways that logging and fire affect the birds, mammals, reptiles and frogs which live in the forest. It will be necessary to extend this work to consider forest invertebrates, but in the short term we consider that management practices which conserve forest vertebrates will also protect forest invertebrates.

The forests of the Eden region are rich in wildlife. Nearly 150 species of birds, 30

A section of forest which in the past was logged and is now regenerating. A characteristic of the regenerating forest is the standard age of the trees rather than the more diverse age structure of unlogged forests. Photo Daniel Lunney.

species of mammals, and over 60 species of frogs, lizards and snakes are found in the forests of southeastern New South Wales. Most are common and widely distributed. None are confined to the region, but some, such as the Glossy Black Cockatoo, *Calyptorhynchus lathami*, and the White-footed Dunnart, *Sminthospsis leucopus*, are uncommon wherever they occur and their survival within the woodchip concession may affect their survival as species.

The immediate effect

A forest changes with the land on which it grows. Some trees grow better on ridges, others in gullies; some are found near the coast, others only at high elevations. The slope of the land, the way it faces the sun, and the rocks which form the soil also affect the forest and favour first one species of plant and then another. Fires, logging and the animals of the forest itself impose other patterns on the landscape. The result is a mosaic of forest types or associations of different species of plants. Within each patch of forest, some trees are old and others young; some are healthy and others dead or dying. Just as the forest changes with the land, so does its wildlife. Each species requires particular kinds of food and shelter (resources). These are not spread evenly through the forest and as resources change in kind and abundance so do the animals which use them.

A study of the effects of forest management on wildlife is a study of where animals occur in the forest, their abundance, and the resources they require. We need to measure how logging and fire affect the kinds of foods and shelter needed by particular species which in turn determines how that species will fare.

The impact of logging on wildlife is least where individual trees are removed selectively and greatest where the native forest is cleared and replaced by exotic pines. Not all animals respond in the same way to disturbance. Some are able to survive the most radical changes, while others are displaced by minor alterations in the structure or composition of the forest. In general, as a forest is simplified and made more uniform, it supports fewer kinds of plants and animals. Animals such as the Greater Glider, *Schoinobates volans*, and Gang Gang Cockatoo, *Callocephalon fimbriatum*, which require mature trees as sources of both food and shelter are the first to be affected. These are the species which are of greatest concern to biologists and pose the greatest challenge to foresters.

It is possible to rank the birds and mammals in a forest according to their dependency on mature forest and hence how sensitive they might be to the effects of logging. Of the mammals in the forests affected by the Eden woodchip industry, the five gliding possums, Greater Glider, Yellow-bellied Glider, *Petaurus australis*, Squirrel Glider, *P. norfolcensis*, Sugar Glider, *P. breviceps*, and Feather-tail Glider, *Acrobates pygmaeus*, and probably a number of species of bats require mature timber.

Among the birds, at least 20 species occurring in the southeast depend on mature forest and are sensitive to the effects of clear-felling. Possibly some frogs and reptiles also require mature forest, but not enough information is available to identify those species which might be affected adversely by pulpwood logging.

Birds and mammals which depend on mature forest commonly require access to trees with hollows. Such trees are known colloquially as 'possum trees' and to wildlife biologists as 'habitat trees'. Such trees are normally old and often quite large. Although they may be suitable as pulpwood, habitat trees generally lack commercial value and may suppress the growth of younger trees. If timber production is to be maximized such trees are removed, and culling of overmature, diseased or otherwise unsuitable trees is normal forestry practice. In commercial terms, the result is a younger, healthier, and more vigorous forest. However, it is also a simpler forest.

Animals which require tree-hollows decrease in abundance and may disappear from forests when old trees are culled. Herein lies the ultimate conflict between forestry and wildlife. Providing for the requirements of wildlife means that the forester may need to accept a lower yield of timber from the forest. Whether this is acceptable depends on the economic, social and environmental value that government assigns wildlife versus timber production. The balance of these values may be largely decided by the political pressure of special interest groups, some of which will want more wood and others more wildlife.

Despite the early fears of environmental groups, the forests affected by the Eden operation have regenerated. Nonetheless, the effect of clear-felling is to replace the complex vegetation of a mature forest with a single layer of regrowth. Initially birds and mammals decline in abundance, but reptiles appear little affected by logging.

As the forest regenerates, some animals respond to the abundant food offered by the lush growth. The new foliage is rich in nutrients and supports an abundance of insects. Ground-dwelling mammals, reptiles and birds which frequent forest edges or dense, low shrubs may become more numerous than in the mature forest. For them, food and shelter are abundant. Brown Thornbills, *Acanthiza pusilla* and White-browed Scrubwrens, *Sericornis frontalis* are particularly abundant in early logging regeneration. However, aboreal mammals and the birds of the forest canopy are absent. For them there is neither food nor shelter.

In work near Bega, we compared the number of birds in 10 to 15 year old regeneration to adjacent areas of mature forest. Information was obtained on fifty species. Numbers for about half these birds were the same in the young as in the mature forest. Of the remainder, half had increased in numbers and half had decreased.

Species adversely affected

The species affected adversely by logging tended to be ones which feed in mature eucalypts. Examples are Gang-gang Cockatoos, and Crimson Rosellas, *Platycercus elegans*, which feed on eucalypt seeds; Spotted Pardalotes, *Pardalotus punctatus*, which take insects from the foliage; Red-browed Treecreepers, *Climacteris erythrops*, which take insects from trunks and large branches; Mistletoe-birds, *Dicaeum hirundinaceum*, which feed on the fruits of mistletoes. When these birds did occur in the regeneration, they were generally in the scattered old trees which had been left standing.

Also disadvantaged by logging were the Glossy Black Cockatoo and Red-browed Finch, *Emblema temporalis*. Both feed on the seeds of Forest She-oaks, *Casuarina littoralis*, a common tree of the forest understorey, which at 15 years are still too young to fruit heavily. She-oaks are not usually felled during logging, but had been culled in the particular area studied.

Regenerating forest, particularly in the gullies, consists of a dense thicket of shrubs and young eucalypts. Not surprisingly, the birds which were more abundant 10 to 15 years after logging than before were frequently birds of dense vegetation; Eastern Whipbirds, *Psophodes olivaceus*, Pilot-birds, *Pycnoptilus floccosus*, and Lewin Honeyeaters, *Meliphaga lewinii*.

Another species at Bega to benefit from logging is the Satin Bowerbird, *Ptilonorhynchus violaceus*. In winter the bowerbird feeds extensively on the fruit of the Native Grape, *Cissus hypoglauca*, a vine which is much more plentiful in regeneration than in mature forest. Similarly, Yellow-tailed Black Cockatoos, *Calyptorhynchus funereus*, benefit from the abundance of wattles (*Acacia spp*) which flourish in the new forest. These parrots feed on borers extracted from the trunks and branches of the wattles.

Regeneration can also support large numbers of small ground-dwelling mammals. Near Eden, Bush Rats, *Rattus fuscipes* and Stuart's Antechinus, *Antechinus stuarti* are abundant in four to five year old regeneration. Following clear-felling the numbers of small mammals decreased, but with regeneration of the forest numbers rapidly built up. As the trees continued to grow and form a tight canopy at about 15 years, the numbers of small mammals fell back to pre-logging levels. Lizards are generally little affected by logging, but a few species benefit from the extra sunlight and heat made available when the trees are removed. Two of the larger skinks, the Black Rock Skink, *Egernia saxatilis* and the common Sphenomorphus, *Sphenomorphus typanum,* are more abundant during the early years of logging regeneration than in the mature forest. Shelter for these animals is also increased by the large amount of logging debris and there may also be more food.

The response of small mammals to integrated logging is similar to that observed after a fire; decline, increase, and decline to pre-fire levels. However, the changes after fire are more extreme and work at Bega has shown that the 1980 fires caused a greater change in the numbers of small mammals than that recorded in the first year after logging. Interestingly the fire appeared to have no more effect on the commoner lizards than did the logging.

The effect of logging or fire, on forest wildlife, varies from species to species according to the kinds of resources required by the species and how these are affected by the disturbance. For example, White-throated Treecreepers, *Climacteris leucophaea,* are abundant in relatively young forests, but the similar appearing Red-browed Treecreeper is uncommon.

Many factors intervene, but, from studies near Bombala, we know that the two treecreepers have different feeding habits and choose different kinds of hollows for nesting. Both forage on the trunks and large branches of trees where they glean from the bark a variety of insects. Ants are a particularly important item of food. The Red-browed Treecreeper probes under loose bark much more often than the White-throated Treecreeper. Loose and hanging bark is something which only develops in abundance as the forest matures and trees become fairly large. Thus the food resource of Red-browed Treecreepers is probably reduced in the young forest relative to that of its congener.

White-throated Treecreepers may also be less choosy about where they nest and use hollows in the trunks of dead trees left standing after logging. In contrast, the Red-browed Treecreeper shows a preference for upward slanting dead limbs attached to large, live trees. This is a resource which is severely depleted by current logging practices. Combined, the different foraging and nesting requirements of treecreepers helps explain why one is less affected by integrated logging than the other.

Information like this is needed to develop management plans for the full array of animals sensitive to the effects of logging and is part of the on-going research program in the southeast.

What we observe in the Eden woodchip concession is not unexpected. The pattern of gains and losses, increases and decreases in the abundance of animals, is similar to that reported for forest regeneration in North America. One can even argue that the immediate effects of clear-felling on wildlife is not really important. What is critical is the age at which a regenerating forest provides all the resources required by wildlife dependent upon mature forest.

The future

The extent of logging associated with the woodchip industry means a major change in the age structure of the forest; old trees are replaced by young ones. The current practice is to log alternate coupes or patches of forest. Each coupe is slightly different in size and shape, but most are about 10 to 20 hectares. A quarter of these have now been cut and by the year 2010 all the mature forest allocated for pulpwood will have been felled and logging will resume on the coupes first cut in the 1970s. Thus a large expanse of mature forest will be replaced by a mosaic of regeneration from newly cut to 40 years old. This, of course, assumes no major change in management objective.

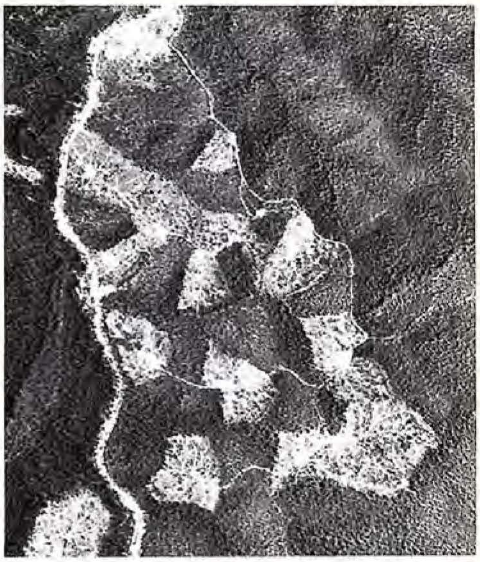
With the reduction in the number of mature eucalypts there may be a reduction in some of the kinds of foods used by forest wildlife. These include eucalypt flowers and fruits, manna (a sugary exudate from eucalypt bark and foliage), the types of insects and their secretions present only on old trees, and the flowers and fruits of parasitic mistletoes; resources which are important to a number of birds and mammals.

Integrated logging will also reduce the number of tree-hollows. Many forest animals of the region use such sites for shelter or nesting; 19 species of birds, 8 species of arboreal mammals, and 10 species of bats are known to require hollows. Research in the Wombat State Forest in central Victoria, which has had a long history of intensive logging, has shown that there is a shortage of tree-hollows and this affects the numbers of arboreal mammals and hole-nesting birds.

A similar situation may occur in southeastern New South Wales as the mature forest is logged and replaced by young trees. Few trees develop hollows suitable for wildlife by 40 years of age. The information that is available suggests that large hollows do not develop in abundance until trees are at least 100 years old.

Small patches and strips of mature forest and even individual trees left in logged areas therefore become important refuges for wildlife. Such areas already retained by forestry include: the scenic reserves along skylines, major roads or rivers, forest which is too steep or rocky for logging, narrow strips of forest left along watercourses (buffer strips) which protect stream channels and reduce turbidity and trees which are unsuitable for either sawlogs or pulpwood. Animals of mature forest which are sensitive to the effects of logging are present in such situations.

The buffer strips along watercourses in particular are vital and form a network of mature forest through the region which will



Top, a number of small logging coupes showing the log dumps and the connecting forestry tracks on the ridges and the snigging tracks leading off into the valleys. Studies by ecologists have indicated that the forest between the logged areas may be too small for the full complement of bird and mammal populations. Photo courtesy of the NSW Department of Lands.

Above, during current operations loggers only take the middle of the tree. The crown of the tree is often left where the tree is felled as it would not be economically viable to use. Photo Daniel Lunney.

An old log indicating a past logging operation. Even 'virgin' forests may have been subject to logging during the past hundred years. At the turn of the century selective logging was carried out, where loggers would only remove certain trees leaving the canopy intact. Photo Daniel Lunney.

assist in the colonization of the young forest as it matures. By enabling animals to move throughout the forest, the network of buffer strips will also prevent sensitive fauna from being fragmented into many tiny populations. These populations might otherwise be too small, for reasons of inbreeding, to survive.

The narrower the buffer strips, the less their value for wildlife, not only because less mature forest will remain in logged areas, but also because trees are more exposed to winds and likely to be blown down. On the other hand, the value of buffer strips as refuges is enhanced if some mature trees remain on the adjacent logged areas. Birds and arboreal mammals have been seen feeding in old trees remaining in the regenerating forest even when the regeneration is too young for their needs.

Buffer strips are also important because of their potential for providing a continuing source of tree-hollows in logging zones. With adequate shelter provided by the buffer strips, animals may be able to use the young forest as a place to feed. In managing wildlife, both food and shelter must be present.

One particularly good source of hollows, although by no means the only one, is the Mountain Grey Gum, *Eucalyptus cypellocarpa,* which is common in gullies and along creeks throughout the southeast. A single tree may have a score of hollows and we have seen trees in which different holes were used simultaneously by four different species of birds and at least two species of arboreal mammals. In the course of time, one tree may provide refuge for the entire range of birds and mammals which require hollows.

The forest managed for pulpwood production will be very different from the mature forest. For many people it will not be particularly interesting or attractive. Other people may find it more attractive. Some animals will be more abundant and others less abundant. As yet, the exact extent of these changes is a matter of judgement and prediction; only time will determine the exact course of events.

Time to act now

Although the woodchip industry means that the forest is changed and that some animals will be scarcer while others increase in number, it does not necessarily mean that the forest is destroyed or that species must be lost. In contrast to a pine plantation, a forest managed for pulpwood in New South Wales is allowed to live. The structure of the forest is greatly changed, but the same kind of tree species regenerate as were present before logging commenced. At least through the first cutting cycle, we can choose to let the forest mature and be reasonably certain that all of its plants and animals will survive. Moreover the procedures adopted to control erosion and protect scenic qualities provide a framework to manage wildlife. No species sensitive to the effects of integrated logging needs to be lost. The means to manage wildlife are available and so, increasingly, is the knowledge of what the forest fauna requires and how it should be provided.

Already ecologists from the Australian Museum and the Forestry Commission have recommended procedures for wildlife management in the forests of southeastern New South Wales. These include widening buffer strips along watercourses to enhance their value for wildlife, connecting buffer strips in different drainages by extending some across ridges, protecting habitat trees from logging, and changing the logging cycle to allow some of the new forest time to mature before it is clear-felled for a second or third time.

As more information becomes available and as more mature forest is replaced by young trees, it may be necessary to propose additional procedures or to change those already recommended. For example, it may prove necessary to retain corridors of mature forest on ridges for animals which do not frequent gullies or watercourses.

The region's parks and reserves may need to be expanded or linked by corridors of mature forest. Management of the Eden forests will need to be dynamic.

Each of the options for wildlife management affects the amount of wood which can be harvested. At least in the short term this means less wood, but it is not certain that it means less wood throughout the commercial life of the forest.

It can be argued that a diverse forest, one with all its attendant plants and animals, may well be a healthier forest and capable of greater sustained production than one where diversity is sacrificed to short-term gains. The less diverse forest may be at an increased risk of attack by insects or disease in much the same way that farm crops are vulnerable to pests.

Currently there is no evidence, at least in the Eden situation, that harvesting of woodchips will lead to a loss in productivity. On the contrary, foresters anticipate that the yield of wood will be higher in the future managed forest than that being obtained from the existing mature forest.

There is time at Eden to consider and test the principles of wildlife management and to assess what we lose and what we gain by managing for wildlife. It may be that the managed forest will yield more wood per hectare. If so, clearly the option is there to maintain a steady production of woodchips (500,000 tonnes per year) and simultaneously manage for wildlife even if this means that wood production is not maximized. However, it is necessary to act now while there is time.

TERANIA CREEK— UNDER THREAT

Terania Creek, one of the last remaining areas of subtropical, closed forest in NSW, is a rich, dynamic and beautiful community of plants and animals. Constantly before the public eye over the past two years, Terania Creek was the subject of a NSW Government inquiry which ran for over 12 months and was estimated to have cost in excess of $1 million. As yet no decision has been made by the Government although it is widely expected that it will favour logging.

The NSW Forestry Commission plans to log the stands of Brush Box which border the rainforest and not to log the rainforest as originally planned. Ecologists believe this will not protect the basin's closed forest ecosystem and consequently oppose the plan. In fact, the classification of forest type appears to be the major disagreement between the foresters and ecologists. The Forestry Commission's classification describes a well developed Coachwood-Crabapple association with an overstorey of giant veteran Brush Box Trees as 'Brush Box' while rainforest ecologists and botanists describe it as 'closed forest' or 'rainforest'. The conflict therefore centres on a point of definition, an argument where the Commission's scheme of forest classification clashes with that adopted by Australia's scientific community.

Terania Creek is a remnant of what was once extensive closed forest in north-eastern NSW. It is impossible to understate the area's importance and it is hoped that the State Government will recognise and preserve what is a natural asset.

by David Milledge

David Milledge is a freelance ecologist who previously worked with the Australian Museum and the NSW National Parks and Wildlife Service on rainforest ecosystems.

The Booyong Reserve near Bangalow is a tiny 18ha reserve and relic of the 75,000ha Big Scrub. Clearly unviable for fauna conservation, it has a road through its centre and is open to the degrading effects of exotic weeds and grazing stock. Photo David Milledge.

Carved into the rhyolitic and basaltic rock layers of the Nightcap Range in north-eastern NSW, Terania Creek basin lies at an elevation of 300m above sea-level. Enclosed and protected by a broken cliff-line the basin narrows into a steep-sided valley draining south into the Richmond River.

Terania Creek is State Forest supporting a dense and luxuriant cover of lowland 'warm', subtropical closed forest or rainforest. The vegetation of the surrounding cliff-line and spurs reaching down into the basin is moist open forest, wet sclerophyll, interspersed with pockets of temperate closed forest. The basin was selectively logged from the 1940s to the 1960s, but the northern half of its area escaped the timber getters and remains virtually undisturbed.

On entering the Terania Creek forest, one is immediately aware of a great richness of plant and animal life. The senses are overwhelmed by the complex structure of the forest, its green luxuriance and rich smells and the profusion of colours and sounds of its animal inhabitants. It is necessary to push through the tangled thickets of regeneration at the southern end of the basin to reach the undisturbed forest where a full experience of the climax subtropical closed forest is obtained.

The experience is worth the effort. The tall closed canopy overhead imparts an almost cathedral-like atmosphere, contrasting with the open nature of the forest floor below. From the floor rise the massive, moss and lichen-encrusted trunks and plank buttress supports of canopy trees such as Yellow Carabeens, *Sloanea woollsii*, and White Booyongs, *Heritiera trifoliata*. The trunks of many trees are meshed with a latticed network of Strangler Fig, *Ficus watkinsiana*, roots and great looping, hanging Water Vines, *Cissus spp.*, as thick as a person's thigh, linking the canopy with the floor. Under the canopy much is in perpetual shade, although occasional slashes of light penetrate the graceful fronds of Bangalow Palms, *Archontophoenix cunninghamiana*, and higher on the trunks of emergent forest giants, more frequent rays of sunlight catch the glossy green fronds of epiphytic Bird's Nest, *Asplenium australasicum*, and Elk Horn, *Platycerium bifurcatum*, ferns. A head-high layer of slender Walking Stick Palms, *Limnospadix monostachyus*, festooned with scarlet fruits in the autumn, completes the effect of structural complexity and through all this permeates the rich, musty odour of rotting wood and leaf litter.

During the day, birds contribute most of the forest sounds, although in summer, cicadas and crickets provide a mechanical, buzzing background that can reach an unbearable pitch. The harsh, drawn-out 'churr' of the Paradise Riflebird, *Ptiloris paradiseus*, is commonly heard and with the explosive notes of Eastern Whipbird, *Psophodes olivaceus*, and Logrunners, *Orthonyx temminckii*, and the eerie 'miaow' of the Green Catbird, *Ailuroedus crassirostris*, adds a strange, exotic quality. In late summer and autumn when the lemon-shaped fruits of Strangler Figs have ripened, the air becomes full of the accelerating, descending 'coos' of brilliantly plumaged green, orange and yellow Rose-crowned Fruit-doves, *Ptilinopus regina*, and the deeper, resonant 'wallocks' and 'woom-poos' of the equally brilliant green, yellow and purple Wompoo Fruit-doves, *Ptilinopus magnificus*.

(continued on page 248)

Above, the stands of Bangalow Palms, *Archontophoenix cunninghamiana*, in the basin are the largest in NSW according to botanist Alex Floyd.

Left, a Giant Barred Frog, *Mixophyes iteratus*. This nocturnal leaf litter frog may be dependent on the closed forest ecosystem.

Opposite, occasional patches of sunlight penetrate the perpetual shade of the closed forest, filtering through the toothed fronds of the palm understorey. Photos David Milledge.

(continued from page 245)

Their calls are accompanied by a steady pattering of pieces of fruit falling to the forest floor as the birds feed. Red and blue Crimson Rosellas, *Platycercus elegans*, and scarlet and bottle-green Australian King Parrots, *Alisteris scapulatis*, add further colour and noise, as do the black and gold male Regent Bowerbirds, *Sericulus chrysocephalus*, and velvet ultramarine male Satin Bowerbirds, *Ptilinorhynchus violaceus*, all attracted by the sweet aromatic flesh of the figs.

Grey-headed and Black Flying Foxes (*Pteropus poliocephalus* and *Pteropus alecto*), replace the fruit-doves, parrots and bowerbirds at night and their harsh, discordant screams drown out the sounds of other nocturnal species that can make the closed forest by night almost as noisy as it is by day. The soft 'plink' calls of blue-grey and rufous Common Ringtail Possums, *Pseudocheirus peregrinus*, advertise their presence to the Sooty Owl, *Tyto tenebricosa*, with its weird 'falling bomb' whistle, the navigating clicks of Eastern Horseshoe and Chocolate Wattled Bats (*Rhinolophus megaphyllus and Chalinolobus morio*), bounce off the undersurface of the canopy, the incessant, high-pitched 'w-r-r-r-k' of Leaf Green Tree Frogs, *Litoria phyllochroa*, provides background and after summer rains, the whirring moans of Red-eyed Tree Frogs, *Litoria chloris*, can be almost deafening. The use of a spotlight will assist in locating the sources of nocturnal animal noises, but stealth is often needed as well in revealing the causes of some, such as the nervous thump, thump, thump of a Red-legged Pademelon, *Thylogale stigmatica*, as it moves away across the forest floor.

Spotlighting also accentuates the structural diversity of the closed forest with the toothed fronds of epiphytic Elk Horn and Stag Horn, *Platycerium superbum*, ferns which are thrown into sharp relief under the canopy. Also individual tree species become highlighted such as the Red Ash, *Alphitonia excelsa*, with its pale silver under-surface and fleshy green, dinner plate-sized leaves identify the Giant Stinging Tree, *Dendrocnide excelsa*.

Lately Terania Creek has become famous, the name a household word throughout eastern Australia. In August 1979 the NSW Forestry Commission opened the area for further selective logging, but this was vigorously opposed by local conservationists. The issue quickly flared into a far wider dispute between NSW conservationists and the alternative society on one hand and the Forestry Commission, the timber industry and the local rural community on the other. In a way it was unfortunate that Terania Creek became a test case because the basin is of particular importance in its own right. On purely ecological grounds it is worthy of reservation because it is one of the few relics of lowland subtropical closed forest in NSW that is likely to remain viable in the long-term future.

Mt Warning National Park, Limpinwood Nature Reserve and Murray's Scrub in Toonumbar State Forest all contain large areas of lowland closed forest although Limpinwood Nature Reserve has been disturbed by past logging and the Forestry Commission plans to log Murray's Scrub in 1982. The Big Scrub Flora Reserve in Whian Whian State Forest contains almost 150ha of lowland closed forest but it too has been logged in the past and is virtually a peninsula, poorly buffered from surrounding pastoral land. Tiny reserves such as the 20ha Johnson's Scrub near Eureka, the 18ha Booyong Reserve near Bangalow and the 14 and 18ha Davis Scrub and Victoria Park Nature Reserves east of Lismore are of little long-term value for conservation. Terania Creek's 400-odd hectares of closed forest is probably large enough by itself to be viable in the long term, but most importantly it is extremely well protected and buffered by the surrounding broken cliff-line and moist open forest.

Botanist Alex Floyd has described four closed forest associations in Terania Creek basin. Much of the floor of the basin is covered with the subtropical Booyong-Yellow Carabeen association while the tributaries and main stream of Terania Creek are bordered with the typically riverine subtropical Bangalow Palm-Blue Fig, *Elaeocarpus grandis*, association. Where the basin narrows into Terania Creek valley and on the upper slopes under the cliff-line, the warm temperate Coachwood, *Ceratopetalum apetalum*—Corkwood, *Ackama paniculata*, association occurs and in areas this carries an overstorey of mature Brush Box, *Tristania conferta*. The warm temperate riverine Callicoma, *Callicoma serratifolia*—Bonewood, *Acradenia euodiiformis*, also occurs along Terania Creek where the basin narrows into the valley. Areas of the moist open forest Brush Box association with a closed forest understorey are found under the cliffs and on spurs running down into the valley. Higher on the spurs and above the cliffs a moist open forest association characterised by Blackbutt, *Eucalyptus pilularis*, predominates. Perhaps the most notable botanical feature of the basin is the density of Bangalow Palms which Alex Floyd has described as the largest stand in NSW.

The vertebrate communities of Terania Creek basin are particularly rich. Sixteen species of frogs, 23 reptiles, 108 birds and 26 mammals occur in the basin's forests. With more work, this total of 173 species is likely to be increased. Approximately 30% of these animals are associated with closed forest, but because of the general lack of information on the ecological requirements of Australia's forest fauna and rainforest animals in particular, we do not know which species are totally dependent upon forest and which might survive in other types of forest. It is likely that many species including the Pouched Frog, *Assa darlingtoni*, the Barred Frogs, *Mixophyes balbus*, Southern Angle-headed Dragon, *Gonocephalus spinipes*, Dwarf Crowned Snake, *Cacophis krefftii*, the Fruit-doves, Sooty Owl, Marbled Frogmouth, *Podargus ocellatus*, Barred Cuckoo-shrike, *Coracina lineata*, White-eared Monarch, *Monarcha leucotis*, Paradise Riflebird, Red-legged Pademelon, the Flying-foxes, the Queensland Tube-nosed Bats, *Nyctimene robinsoni*, and Blossom Bats, *Syconycteris australis*, and the Fawn-footed Melomys, *Melomys cervinipes*, do depend upon closed forest and can only survive where there are relatively large areas of closed forest. Others will find their requirements in both closed forest and the adjacent moist open forest, which generally form a complex mosaic in northern NSW. A point worthy of note is that because of the closeness of logged and unlogged closed and moist open forest in Terania Creek basin, an ideal situation exists for research into the relationships of the vertebrate communities of these two forest types and on the effects of logging on rainforest fauna.

Epiphytic Bird's Nest Ferns, *Asplenium australasicum*, on a fig, components of the rich structural diversity of the subtropical closed forest. Photo David Milledge.

Sixteen of the vertebrates recorded in the basin are considered rare or uncommon in NSW and the Crested Hawk, *Aviceda subcristata*, Wompoo Fruit-dove, Marbled Frogmouth and Albert's Lyrebird, *Menura alberti*, are classed as rare and endangered by the National Parks and Wildlife Services (NSW). This concentration of uncommon and rare species in an area of approximately 750ha (combined area of closed and moist open forest in the basin) is high and emphasises the importance of Terania Creek for the conservation of forest fauna in New South Wales.

Of the vertebrates depending on the closed forest, some are likely to require mature or undisturbed forest. Again because of the lack of information on their ecological requirements, it is not possible to list these species categorically. An example is probably the Marbled Frogmouth. This nocturnal closed forest specialist is predominantly a ground feeder, swooping down from its lookout perch on a vine or the branch of an understorey tree to snap up invertebrates on or near the ground. Disturbance caused by logging or roading in the closed forest results in a proliferation of pioneer plant growth forming a dense ground and understorey cover which would considerably disadvantage a bird with these feeding habits. The floor of a mature (understoreyed) rainforest is largely bare of plants. The Marbled Frogmouths of Terania Creek basin are of special interest. There may be as many as 10 resident pairs of this Frogmouth in the basin, which, if correct, makes Terania Creek the NSW stronghold of this rare and poorly known species.

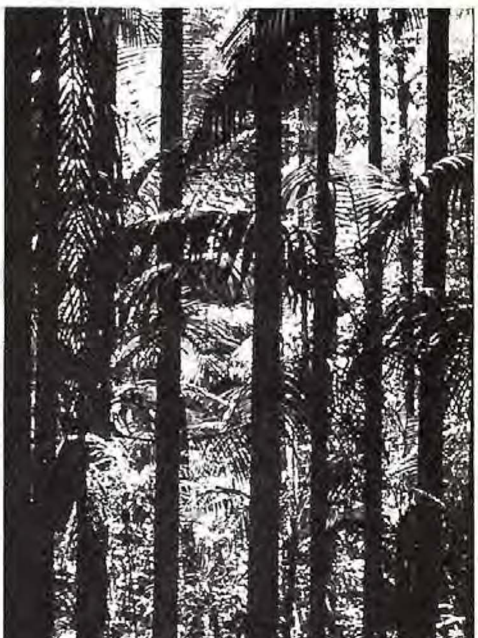
A feature of the vertebrate fauna of the basin's rainforest is that it is distinct from that of similar closed forests at higher altitudes in NSW. Most of the lowland rainforest in NSW has been cleared for agriculture and the animals associated with these forests have been affected more by European settlement than any other forest fauna in the State. The vertebrate communities of the basin probably closely resemble that of the former Big Scrub, an area of approximately 75,000ha of lowland closed forest which once stretched from Lismore to Bangalow. Except for a few isolated relics, the Big Scrub has been entirely cleared for agriculture. Our opportunities for conserving examples of this forest and its animal communities are therefore extremely limited.

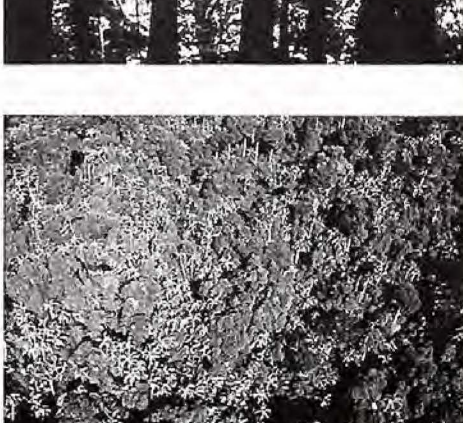
The differences between lowland and highland subtropical closed forest faunas can be illustrated by their birdlife. Censuses of birds in Terania Creek (200 and 300m above sea level) and on Mt Nardi (700 and 800m above sea level) have shown that species such as the Rose-crowned, *Ptilinopus regina*, and Wompoo Fruit-doves, Noisy Pitta, *Pitta versicolor*, Pale Yellow Robin, *Tregellasia capito*, Little Shrike-thrush, *Colluricincla megarhyncha*, Spectacled Monarch, *Monarcha trivirgatus*, and Paradise Riflebird are more abundant at lower altitudes. Other species resident in the basin and characteristic of lowland closed forests include the Varied Triller, *Lalage leucomela*, White-eared Monarch, Figbird, *Sphecotheres viridis*, Spangled Drongo, *Dicrurus hottentottus*, and Regent Bowerbird. Some tree frogs and skinks, the Red-legged Pademelon, the Grey-headed and Black Flying-foxes and the Queensland Tube-nosed and Blossom Bats are also most abundant in lowland subtropical closed forests and well represented at Terania Creek.

The basin has an additional important function. The Nightcap Range, enclosed within Goonimbar and Whian Whian State Forests, is an 'island of forest' set in a sea of land cleared for pastoral development. There is a tenuous connection across the Doon Doon saddle to the Koonyum Range contained in Nullum State Forest, but this too is a forest island and has been disturbed by logging. Terania Creek contains the largest area of undisturbed closed forest in this forest island and may effectively act as a reservoir of species requiring mature forest which could then recolonise other parts of the forest.

The NSW Forestry Commission's insistence that it will only log the Brush Box stands (moist open forest) and that the rainforest (closed forest) will be preserved is a semantic argument which will not result in the protection of the basin's closed forest ecosystem. Much of the Commission's typing of Brush Box contains forest which must be considered closed forest ecologically. This is principally the well-developed Coachwood-Crabapple association with an overstorey of giant veteran Brush Box trees, many of which are likely to be over 1,000 years old as indicated by carbon dating tests and as such should be conserved in their own right. Roading and snigging tracks on which the logs are pulled will cut through the Booyong-Yellow Carabeen and Bangalow Palm-Blue Fig associations and because of the basin's steep-sided slopes, it would be impossible to prevent damage to the subtropical associations below when many of the mature trees are felled.

The world's rainforests are being destroyed at an ever increasing rate and there seems little chance that significant areas of lowland rainforest will survive for future generations. Terania Creek is a remnant of once extensive closed forest in northeastern New South Wales. It is a rich, dynamic and beautiful community of plants and animals which, if preserved, will give the people of Australia access to a unique assemblage of plants and animals. Terania Creek's importance can be realised when we consider the small amount of untouched rainforest left on the east coast of Australia.





Above, selective logging of a stand of Brush Box, *Tristania conferta*, in Whian Whian State Forest east of the Terania Creek basin, showing the gaps created in the canopy and the degree of disturbance of the understorey and ground layer below.

Right, ground level in Terania Creek basin. Dense subtropical closed forest covers the floor of the basin with moist open forest on the surrounding ridges extending down into the basin on spurs.

Below, the undisturbed closed forest at the northern end of the basin is characterised by giant emergent White Booyongs, *Heritiera trifoliata*, Yellow Carabeens, *Sloanea woollsii*, and Strangler Figs, *Ficus watkinsiana*, towering over the canopy. Photos David Milledge.

. . . AND FOREST BIRDS

The breeding periods of Australia's woodland birds vary considerably due to a number of variables, the most important of which is favourable weather conditions. Stephen Marchant, the recently retired editor of *The Emu*, the journal of the Royal Australasian Ornithologists Union, has been studying the birds in his region for the past six years and has been able to observe their breeding behaviour first hand.

by S. Marchant

The Spotted Pardalote, *Pardalotus punctatus*, is an irregular breeder in the Moruya area which usually starts to lay its first egg during September. This is earlier than the time the bird breeds elsewhere, namely October to January. Spotted Pardalotes usually nest at the end of tunnels on river banks or cliff faces. With the male generally taking the initiative in selecting a site, both birds then set about to build the nest. They dig a burrow some 5cm long and build a nest consisting of fine bark fibre and grass. The female usually lays four eggs and both parents share the incubation duties and care for the young. Photo R. B. Legge.

Opposite, the Superb Fairy Wren, *Malurus cyaneus*, is a regular breeder in the Moruya district, regularly laying its eggs in October. This wren is a common inhabitant of south-eastern Australia, usually breeding between September and March. Superb Fairy Wrens live in groups which can contain several adult birds. By living a group life, Superb Fairy Wrens can breed several times in rapid succession providing the seasonal conditions are at an optimum. Female Superb Fairy Wrens are sufficiently liberated as the adult males take care of the nestlings when they fledge, giving the female the chance to nest again. Later in the season members of earlier broods assist the parents by helping to feed the younger, more recent arrivals. Photo L. Robinson.

It is difficult and somewhat dangerous to generalise on the breeding seasons of Australia's birds, as the onset of breeding is controlled to a very large degree by favourable weather conditions. Although this probably applies more to inland areas, my experience, since 1975 at Moruya on the southern NSW coast, suggests that it applies there too.

Only the birds of woodlands which are regular breeding species and whose nests are more accessible in the small area around my house have been studied. Many common species nest in high trees or in holes so that exact breeding details are impossible to get whereas others breed so sparsely in the area that their nests are not found each year.

Studies began in 1975 and for each of the first four years there was more than average rainfall (1000mm), however, as the pattern of breeding was much the same throughout that time period I have taken those years to represent normal years. Drought began from March 1979 but its effect was not immediately noticeable. By autumn and winter 1980 it had become quite severe. This, coupled with two fires, on 23 April and 11 August, which together burnt out most of the study area, disrupted the breeding season that year. Despite poor breeding the pattern of nesting which did occur seemed little different from previous years.

Some useful rain fell between February and May 1981 stimulating regeneration of the vegetation and leading to a later infestation of lerps. By late September it was already becoming clear that some species were breeding considerably earlier than usual or in larger numbers or both.

Flowering of the gum trees also undoubtedly influences the incidence of breeding. Forest Red Gums, *Eucalyptus tereticornis*, flowered profusely during 1977 and in 1978 the Spotted Gums, *E. maculata*, did likewise. As a result noticeable differences in breeding, especially among honeyeaters, occurred during both years.

If the years 1975-78 can be taken as normal, one can safely say that almost no species in the woodlands starts to breed before 1 August or continues after 31 December. With nesting restricted to this period the laying of the first egg in a clutch proves to be physiologically crucial for a breeding cycle. Once that first egg is laid the pattern is set for more eggs. If, however, the laying of the first egg is delayed the breeding season will be shortened and the total number of eggs laid during the season will be considerably less.

Of course, occupied nests with eggs or young may persist into January or February and I have found a few where laying started after 1 January.

There seems to be two winter-breeding species in the woodlands: the Superb Lyrebird, *Menura novaehollandiae*, and White's Thrush, *Zoothera dauma*. The first is known to breed in winter wherever it has been studied and all the eggs found have been laid in June. The second is so rarely recorded here between the middle of October and the middle of March that I regard it as a winter-breeding visitor whose first nests appear in late July or early August. There are other early nesters but my data are inadequate to decide how regularly they start nesting before August.

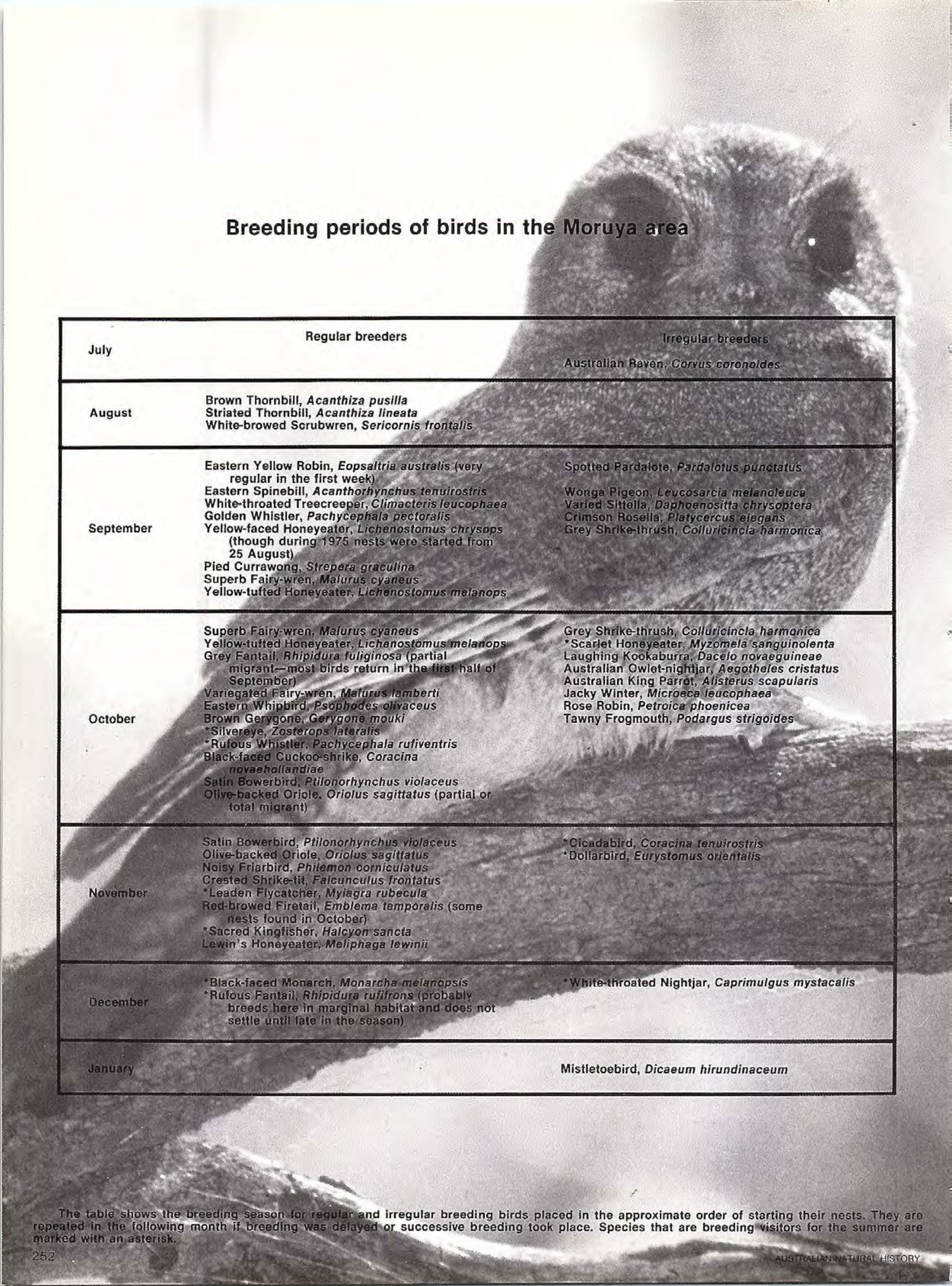
One pair of New Holland Honeyeaters, *Phylidonyris novaehollandiae*, is normally resident and I have twice found nests started in July. Striated Thornbills, *Acanthiza lineata*, probably start to build in July and may lay before the end of the month. However, as at least half their nests occur in treetops, it is almost impossible to get details. Crescent Honeyeaters, *Phylidonyris pyrrhoptera*, nested only in 1978 when the Spotted Gums bloomed and at least one nest was started at the end of July.

During the more regular years of the study period the breeding season always started in earnest during August. Generally nesting fell off rapidly after the middle of December which appears to be when the average daily maximum temperatures reach and remain at 30°C. By that time it is usually rather dry and the vegetation is becoming desiccated.

Even if substantial rain falls in January, as happened during 1976 and 1978, there is no resumption of nesting. From then until June, when the Lyrebirds start, I have only found new nests of Red-browed Firetails, *Emblema temporalis*, and occasionally some other species in January.

This does not mean that every species, once it has started to nest, continues to do so until December. Those species that, in the unlikely event of full success, rear several broods in a season continue to start new nests until December. Examples are Yellow Robins, the two Whistlers, Grey Fantail, the two Fairy-wrens, White-browed Scrubwrens, Brown Gerygone, Yellow-faced Honeyeaters and Eastern Spinebills. Most nests, however, fail and I have known some colour-marked individuals to make six or seven nesting attempts in a season.

While most nests fail, some species whose first brood is successful lay replacements in the case of an early loss and skip a second brood. This is hard to prove but the Crested Shrike-Tit, Brown Thornbill, Tree-



Breeding periods of birds in the Moruya area

	Regular breeders	Irregular breeders
July		Australian Raven, *Corvus coronoides*
August	Brown Thornbill, *Acanthiza pusilla* Striated Thornbill, *Acanthiza lineata* White-browed Scrubwren, *Sericornis frontalis*	
September	Eastern Yellow Robin, *Eopsaltria australis* (very regular in the first week) Eastern Spinebill, *Acanthorhynchus tenuirostris* White-throated Treecreeper, *Climacteris leucophaea* Golden Whistler, *Pachycephala pectoralis* Yellow-faced Honeyeater, *Lichenostomus chrysops* (though during 1975 nests were started from 25 August) Pied Currawong, *Strepera graculina* Superb Fairy-wren, *Malurus cyaneus* Yellow-tufted Honeyeater, *Lichenostomus melanops*	Spotted Pardalote, *Pardalotus punctatus* Wonga Pigeon, *Leucosarcia melanoleuca* Varied Sittella, *Daphoenositta chrysoptera* Crimson Rosella, *Platycercus elegans* Grey Shrike-thrush, *Colluricincla harmonica*
October	Superb Fairy-wren, *Malurus cyaneus* Yellow-tufted Honeyeater, *Lichenostomus melanops* Grey Fantail, *Rhipidura fuliginosa* (partial migrant—most birds return in the first half of September) Variegated Fairy-wren, *Malurus lamberti* Eastern Whipbird, *Psophodes olivaceus* Brown Gerygone, *Gerygone mouki* *Silvereye, *Zosterops lateralis* *Rufous Whistler, *Pachycephala rufiventris* Black-faced Cuckoo-shrike, *Coracina novaehollandiae* Satin Bowerbird, *Ptilonorhynchus violaceus* Olive-backed Oriole, *Oriolus sagittatus* (partial or total migrant)	Grey Shrike-thrush, *Colluricincla harmonica* *Scarlet Honeyeater, *Myzomela sanguinolenta* Laughing Kookaburra, *Dacelo novaeguineae* Australian Owlet-nightjar, *Aegotheles cristatus* Australian King Parrot, *Alisterus scapularis* Jacky Winter, *Microeca leucophaea* Rose Robin, *Petroica phoenicea* Tawny Frogmouth, *Podargus strigoides*
November	Satin Bowerbird, *Ptilonorhynchus violaceus* Olive-backed Oriole, *Oriolus sagittatus* Noisy Friarbird, *Philemon corniculatus* Crested Shrike-tit, *Falcunculus frontatus* *Leaden Flycatcher, *Myiagra rubecula* Red-browed Firetail, *Emblema temporalis* (some nests found in October) *Sacred Kingfisher, *Halcyon sancta* Lewin's Honeyeater, *Meliphaga lewinii*	*Cicadabird, *Coracina tenuirostris* *Dollarbird, *Eurystomus orientalis*
December	*Black-faced Monarch, *Monarcha melanopsis* *Rufous Fantail, *Rhipidura rufifrons* (probably breeds here in marginal habitat and does not settle until late in the season)	*White-throated Nightjar, *Caprimulgus mystacalis*
January		Mistletoebird, *Dicaeum hirundinaceum*

The table shows the breeding season for regular and irregular breeding birds placed in the approximate order of starting their nests. They are repeated in the following month if breeding was delayed or successive breeding took place. Species that are breeding visitors for the summer are marked with an asterisk.

creeper, Shrike-thrush, Friarbird, Lewin's Honeyeater, Oriole and Currawong probably all fall into this category.

The Thornbill, White-throated Treecreeper and Pied Currawong do not begin new nests right through the season. During the study period only two nests of Brown Thornbills were started after 17 October, only one of the Treecreeper after 1 November and one late nest of Pied Currawongs was started on 1 December. Late starters like Shrike-Tits and Friarbirds will often start replacement nests in December.

Some species are probably strictly double-brooded (Striated Thornbills, Eastern Whipbird) but again, because the Thornbill starts early, its effort ends in November and I have known no nest of this species to be started after 20 November. The Whipbirds certainly once started a second brood on 20 December. The New Holland Honeyeater deserves a special mention. The only pair in my area normally start nests from mid-July to late October, attempting to rear two or more broods. In 1977, when the Forest Red Gums flowered in September and October, at least five other pairs settled in their vicinity and nested, the last starting on 28 November which is the latest nest of the species that I have ever known.

Apart from the flowering of the Red Gums in 1977 and that of the Spotted Gums in 1978, the four years 1975-78 seemed quite similar with regard to the pattern of breeding. However, in 1977 there was considerably less rain during late autumn and winter (May-June) than in the other years and temperatures rose into the thirties (°C) much earlier (October versus November). As a result breeding was generally less. I could only find about 125 nests in my study area instead of the 200 or more of other years. Moreover, nesting declined rapidly after about 25 November rather than after mid-December. Though I paid less attention to general nesting in 1979, I found a good number of nests and

Top, a male Golden Whistler, *Pachycephala pectoralis*, is a regular September breeder in Moruya. Golden Whistlers have no definite migratory pattern but do cover a large amount of area in their locality. They commonly lay two eggs. Photo P. Green.

Centre, the Olive-backed Oriole, *Oriolus sagittatus*, is a migratory bird in south-eastern Australia and is first seen as breeding pairs during October. Olive-backed Orioles are well known mimics which eat native fruits and insects. Photo I. R. McCann.

Lower left, Eastern Yellow Robin, *Eopsaltra australis*, is a punctual breeder always laying its first egg during the first week of September. Studies of these birds have shown that a breeding pair occupy the same area in successive seasons. Eastern Yellow Robins are known to brood up to three times in a season with nest building taking about a week and incubation 15 days. The birds usually lay three eggs. Photo L. F. Schick.

Lower right, the Striated Thornbill, *Acanthiza lineata*, is a regular breeder during the August months. In non-breeding seasons Striated Thornbills gather in flocks and can remain in that same group for up to five years. Photo A. J. Salter.

The White-browed Scrub Wren, *Sericornis frontalis*, is probably the best known and most widely distributed small ground-feeding bird in the forests of eastern and southern Australia. In the Moruya district, it nests regularly during August which corresponds to its general July-January season throughout Australia. The nests of this bird are dome-shaped, having a rounded side-entrance and usually made of bark strips, rootlets and grasses and lined with feathers. Juveniles despite having a few months to move about freely, establish a territory fairly quickly and then remain completely sedentary. Photo W. J. Labbett.

noticed no substantial differences from the pattern of the four previous years.

The effect of drought became apparent in 1980 and the burning of the area in autumn and winter of that year brought about considerable changes. Most noticeably, Yellow-faced Honeyeaters, Brown Thornbills and Spotted Pardalotes were virtually eliminated, probably because nesting sites or food or both were destroyed.

No low vegetation or shrubs were left in which the Thornbills and Honeyeaters could nest and the trees had not yet started to sprout and provide other nesting sites for the Honeyeaters.

The Pardalotes could have found nesting sites in the banks as usual but their food must have gone because all leaves to the treetops were singed off. Striated Thornbills, Scrub-wrens, Fairy-wrens, Grey Fantails and Silvereyes were apparently reduced in numbers and even if the numbers of Whistlers, Whipbirds and Treecreepers appeared the same (certainly most marked individuals survived the fires), probably most did not try to breed. For instance, an old pair of Golden Whistlers, both birds colour-banded, were in the area the whole season but I could not find their nest or nests. The same occurred with the regular pair of Whipbirds. I also had the impression that more sparsely distributed species like Cicadabirds and Bowerbirds did not try to breed, though this was impossible to prove.

Curiously, the Yellow Robins were unaffected. All my marked individuals survived the fires and nested in their usual territories at a somewhat earlier time than was usual. Other surprises were that three pairs of Flame Robins, *Petroica phoenicea*, never recorded in the area before, appeared a week or two after the fire on 11 August and bred in burned-out areas. Also that a pair of Common Bronzewings, *Phaps elegans*, previously rarely seen round my house, settled during the winter after the fire of 23 April and bred in August. Finally a Horsfield's Bronze-cuckoo, *Chrysococcyx basalis*, normally never found in the woodlands, laid its eggs in the nest of Superb Fairy-wrens twice. Apart from the Yellow and Flame Robins, the only nests that I could find in 1980 (which were far fewer than in previous years) were in small patches of bush of less than half a hectare, that had miraculously escaped the fires.

There was not much regeneration of the vegetation until February, 1981, when there was some substantial rain, with more in April and May. Conditions seemed quite encouraging during March and evidently some species were stimulated towards breeding. Unhappily I could not do much regular fieldwork at that time but, even during casual observations, I found Yellow-tufted Honeyeaters building on 26 March, Yellow-faced Honeyeaters on 29 March and Yellow Robins on 2 April. Spotted Pardalotes were prospecting nesting sites at the end of March and Brown Thornbills had a completely built nest on 24 June. As far as I knew, none of these nests received eggs.

A feature of the cauliferous regeneration of the gum trees that occurred during the winter was the infestation by lerp, which attracted large numbers of honeyeaters, especially Yellow-faced, Fuscous and White-naped, and Pardalotes. It is presumed that the lerps abundance enabled these species, excepting the Fuscous Honeyeater, to start breeding earlier than usual and at least for the Pardalotes, in much greater numbers than in other years.

Writing in late September, I can safely say that for several species the season is earlier than in any previous year. Striated Thornbills started nests in early July, Yellow Robins by 1 August, Brown Gerygone by about 1 September, Yellow-faced Honeyeaters by mid-August and Yellow-tufted by 26 August. Spotted Pardalotes were building in mid-July and now have young out of the nest while Noisy Friarbirds are building. Golden Whistlers, New Holland Honeyeaters and Pied Currawongs seem to have started nests about the normal time.

I have deliberately not mentioned cuckoos as they can breed only when their hosts are doing so, but there are many puzzles regarding the way their nesting is synchronised to other birds cycles. Only the Brush Cuckoo, *Cuculus variolosus*, seems to arrive in good time to lay its eggs in the nests (parasitise) of the Fantails and Flycatchers, its normal hosts. I found its eggs only in December 1975. Some Fan-tailed Cuckoos, *Cuculus pyrrhophanus*, and Shining Bronze-cuckoos, *Chrysococcyx lucidus*, may spend the winter in the district but neither seem active or noisy from April to August. They become prominent from about 20 August when it is probably already too late for them to catch the first nests of Thornbills and Scrubwrens, which they usually parasitise. Most eggs or young of Fantails that I have seen, have been in Scrubwren's nests, laid between 12 October and early December, except once on 19 September. I have found only one egg of the Shining Bronze-cuckoo laid in late November. The clutch size and laying routine of individual Fantails is a mystery and perhaps several females operate in the area, accounting for the spread of laying.

The Channel-billed Cuckoo, *Scythrops novaehollandiae*, which in Moruya is at the southern limit of its range, is especially curious. It arrives in early October, probably too late for most nests of Pied Currawongs which are really its only feasible host. Currawong nests prove to be its main host because Ravens and Magpies are much earlier nesters. The Cuckoos stayed only for a week or two, yet successfully parasitised one Currawong's nest in 1980. They may not be able to find suitable nests to parasitise every year.

I have left much unsaid about the species discussed, let alone nocturnal birds, birds of prey, parrots, some honeyeaters and other passerines that nest high, but it has seemed better to consider only what can be based on good evidence rather than speculate on the strength of one or two nests seen occasionally.

If the whole avifauna of the district was covered, it would probably be found that breeding occurred throughout most of the year. Ducks undoubtedly start to lay in late autumn and early winter while shorebirds like Little Terns, *Sterna albifrons*, have hard competition for use of sandy beaches with holiday-makers in January and February.

Therefore it seems some breeding occurs in the district in every month of the year, even if most is confined to the last six months. What is clear is that the breeding period of many woodland species can vary quite considerably and that details of such variations can be understood only after years of study.

CENTREFOLD No. 10

Western Barred Bandicoot, *Perameles bougainville*

by A. A. Burbidge

The Western Barred Bandicoot builds a well concealed nest emerging at dusk to forage for food. Photo A. G. Wells.

The Western Barred Bandicoot exists now only in the nature reserve constituted by Bernier and Dorre Islands in Shark Bay, WA. It is probable that, prior to European settlement, it extended over much of the southern half of Australia but the situation is confused by the variety of names given by early taxonomists to local populations: *Perameles bougainville* from Shark Bay, *P. myosura myosura* from King George Sound, WA, *P. myosura notina* from St Vincent Gulf, SA, and *P. fasciata* from the Liverpool Plains, NSW. Since these mainland forms are now extinct and few museums specimens exist, it is unlikely that the relationships between them will ever be resolved. For the purposes of this account, it is considered that all are forms of the Western Barred Bandicoot.

It is an inhabitant of semi-arid areas with a variety of vegetation types. In southwestern Western Australia it was found in dense scrub and particularly favoured thickets of Casuarina seedlings. In southeastern Western Australia and the southern half of South Australia it lived in open salt bush and blue bush plains. In Victoria and western New South Wales it was recorded from stony ridges. On Bernier and Dorre Islands, it is especially common in sandhills behind beaches.

During the day it occupies a nest which is usually well concealed and difficult to locate, made from grasses and other vegetation in a hollow dug under a low shrub. Two animals may occasionally share one nest. At late dusk it emerges to forage for food which includes insects and other small animals, seeds, roots and herbs obtained by digging or hunting.

Little information on breeding is available. In South Australia, animals were reported to have bred in winter and, on Bernier and Dorre Islands, breeding has been recorded in autumn and winter. Two young are usually carried in the pouch but litters of 1-3 have been recorded.

Size: Head and body length 200-300(240)mm; tail length 75-120(90)mm; and weight 190-250(220)g.

Identification: Light grey to brownish grey above, white below. Feet white. Two or three alternating paler and darker bars across the hindquarters, pronounced in some populations but muted in others (for example Bernier and Dorre Islands). Large, erect ears. Distinguished from Desert Bandicoot by colour and by shorter tail.

Synonyms since 1934: *Perameles fasciata, Perameles myosura.*

Other common names: Barred Bandicoot, Eastern Barred Bandicoot, Sharks Bay Striped Bandicoot, West Australian Striped Bandicoot, South Australian Striped Bandicoot, New South Wales Striped Bandicoot, Marl, Little Marl, Nyemmel (Aboriginal, Albany, WA).

Marl appears to be derived from *Mala*, quoted by Gould as the Aboriginal name for the Barred Bandicoot from the Toodyay district of WA. This is actually the Aboriginal name of the Rufous Hare-wallaby over much of Western Australia and its application to a bandicoot is confusing.

Survival status: Abundant on Bernier and Dorre Islands, presumed extinct on mainland.

Subspecies:

Perameles bougainville bougainville, Shark Bay

Perameles bougainville fasciata, Victoria, New South Wales

Perameles bougainville myosura, South-western Western Australia

Perameles bougainville notina, South Australia, south-western Western Australia

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. Dr Andrew Burbidge is the Chief Research Officer at the West Australian Wildlife Research Centre, part of the Department of Fisheries and Wildlife. He has been responsible for considerable faunal surveys throughout Western Australia, particularly in the little known north-west of the state.

FURTHER READING

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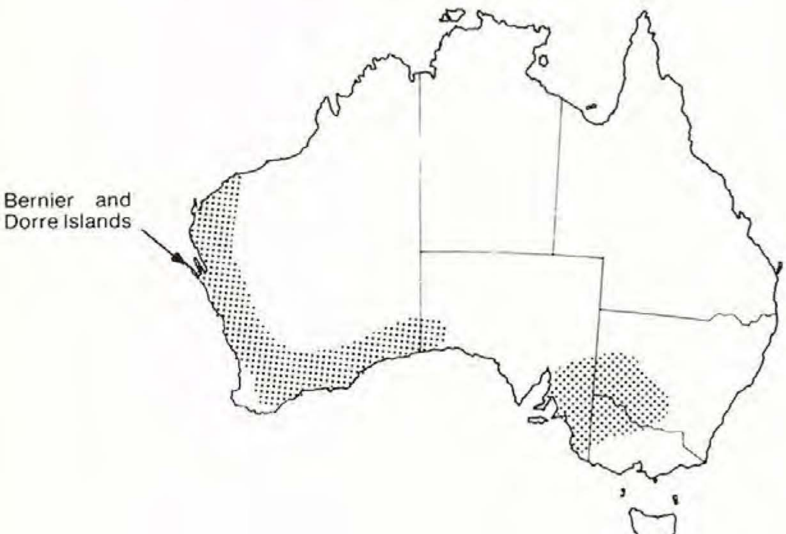
The Western Barred Bandicoot, *Perameles bougainville*, only exists on Bernier and Dorre Islands. Before European man's arrival it probably extended over much of southern Australia inhabiting a variety of vegetation types. Photo A. G. Wells.

Perameles Bougainville

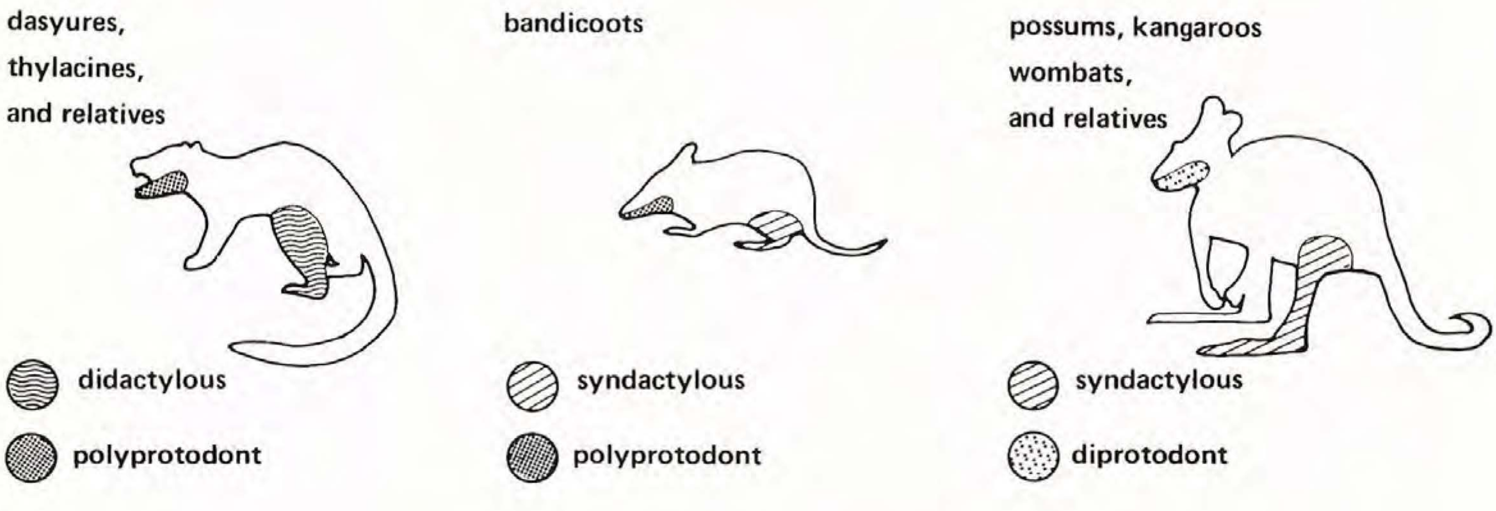


Previous range of *Perameles bougainville*

Existing range is confined to Bernier and Dorre Islands

Class: Mammalia
Order: Marsupialia
Family: Peramelidae
Genus: *Perameles*
Species: *P. bougainville*
Common Name: Western Barred Bandicoot

Bandicoots — the 'missing link'



The omnivorous bandicoots fall into two families: the Thylacomyidae, or rabbit-bandicoots, and the Peramelidae, or ordinary bandicoots. All are syndactylous (having the second and third toes of the hind foot joined), as are possums, kangaroos and wombats. However, unlike these syndactylous marsupials which are diprotodont (having only two lower incisor teeth), bandicoots are like dasyures and thylacines in being polyprotodont (with at least four lower incisors). Bandicoots thus represent a 'missing link' between the two major groups of Australian marsupials.

The diagram and extract are from the book, *Mammals In Australia*, by Michael Archer, recently published by the Australian Museum and available from the Museum for $5.50.

'HERE'S SMOG IN YOUR EYE'

by Sandy Thomas

Motor vehicle exhaust emissions being tested at the NSW State Pollution Control Commission's laboratories in Lidcombe, Sydney. The introduction of unleaded petrol and catalytic converters in the mid-1980s will reduce the emission of pollutants while simultaneously improving fuel economy.

Above right, the fine, sunny days which make Sydney so attractive in summer also lead to its most serious air pollution problem: the production of photo-chemical smog. The principal source of the pollutants which react to produce photochemical smog is the motor vehicle. Photos courtesy of the NSW State Pollution Control Commission.

In Sydney, gritty eyes are not just the result of stray pieces of dirt, nor late nights and too much alcohol. Air pollution is to blame. In fact, Sydney has the worst air pollution of any of the Australian capital cities. Surveys of public attitudes show there is a large awareness of air pollution in Sydney and that there is a strong base of community support for stricter controls and the need for greater public expenditure to combat the problem.

The NSW State Pollution Control Commission (SPCC) recently initiated what are pioneering anti-pollution recommendations in Australia and received strong support from the State Government in the form of legislation. These new laws provide for the availability of lead free petrol at all retail outlets where petrol is sold by July, 1985 and its use in all petrol vehicles manufactured after January, 1986. Passed as Amendments to the Clean Air Act of NSW on the 10th June, the regulations are at present being prepared. Similar legislation to the NSW laws is presently being enacted by each of the other states.

Sandy Thomas is a Scientific Officer and Editor at the State Pollution Control Commission. During the past two years he has been deeply involved in the work to find a solution to Sydney's air pollution problem.

On a clear day you can see for ever—but on a fine, still winter's morning in Sydney about six kilometres may be closer to the mark.

If you're exercising vigorously in Sydney on a sunny summer day, any breathing difficulties or chest pains may not be the result of physical unfitness—they could be caused by the air you breathe.

And if you have children who live or study in an area where traffic densities are high, it is possible that their nervous systems and intelligence are being subtly harmed by the emissions from motor vehicle exhausts.

Sydney has the worst air pollution of any of the Australian capital cities. Every day several thousand tonnes of carbon monoxide, hydrocarbons, nitrogen oxides, sulphur oxides and particulates such as soot and lead are poured into its atmosphere, and many of these pollutants remain there for a considerable period of time, often reacting with one another to produce even more harmful secondary pollutants. But Sydney's problems are by no means unique—all the problems are experienced to a great extent in other major Australian cities.

Three main problems

The three main air-pollution problems in Sydney are those alluded to above: the 'brown haze' experienced during the colder months of the year, photochemical smog, which is most common during summer, and atmospheric lead pollution.

The causes of these three problems are often closely related, as are many of the methods of bringing them under control, but the pollution problems themselves are distinct. Each is considered separately below, and possible control strategies are then discussed.

The most immediately apparent air pollution for most residents of Sydney is the unsightly grey to brown haze that hangs over the city and suburbs on many crisp and otherwise clear mornings from autumn to spring.

Although commonly called 'smog', this haze, consisting mostly of fine particles suspended in the air, is not associated with photochemical smog. It is essentially a phenomenon of cool nights and mornings, whereas photochemical smog occurs most intensely on warm summer late mornings and afternoons.

The nature and origin of the brown haze have been intensively investigated in recent years. The CSIRO Division of Process Technology at North Ryde and a group from the School of Earth Sciences at Macquarie University, with assistance from the State Pollution Control Commission (SPCC), have studied the distribution, composition and sources of the haze and the meteorological factors influencing its formation, circulation and dispersion. Another investigation involving the SPCC and the Australian National University has sought to use radiocarbon dating techniques to trace the sources of the carbon components of the haze.

The CSIRO and Macquarie University studies have utilised both ground-based monitoring results and airborne surveys. The results of haze-intensity and meteorological measurements and aerosol-sample analyses have then been compared with the known characteristics of motor vehicle emissions, bushfire smoke and soil and cement dusts in an attempt to identify the sources of the haze.

To date the main findings of these studies have led to the following information.

The haze forms mainly during the cooler months of the year, when longer nights and clear skies favour the formation of temperature inversions at 150-300m, trapping pollutants in the fairly uniform, westerly-drainage layer of air below the inversion. The haze intensity peaks at about 9am, and weakens near midday with the breakdown of the inversion and westerly drainage flow and the onset of convection or seabreezes. Haze intensity then builds up again at around 10pm, as polluted air is carried inland by afternoon seabreezes and then back towards the coast during the late evening by the westerly drainage flow. It peaks at around midnight before declining again prior to the 9am peak.

The haze is widespread, covering the bulk of the urban area, and extending, when there is a westerly air flow, many kilometres out to sea.

The composition of the haze is remarkably uniform geographically, with 80% being fine particles smaller than 1.5μm in diameter and thus having a greater potential to affect the human respiratory system than larger particles. The major constituents of these particles are, on average, carbon (30%), sulphate (12%), sodium (9%), nitrate (8%), chloride (7%), silicon (3%) and lead (2%). Potassium, calcium, zinc and aluminium also contribute more than 1% of the mass of the haze.

A preliminary breakdown of the average mass contribution of likely sources is motor vehicles 17% (increasing to 20% in the morning peak period), sea salt 17%, backyard burning and bushfires 10%, and soil and cement dusts 5%. The sources of the remaining 52% of the mass of the haze cannot be confidently identified but process heating and refuse incineration are believed to be largely responsible.

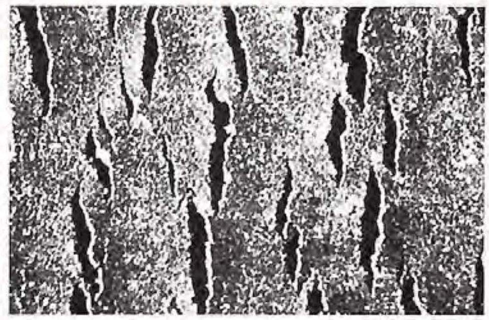
A preliminary breakdown of the average contribution of these sources to visibility degradation is motor vehicles 24%, sea salt 3%, vegetative burning 10%, soil and cement dusts 1% and unspecified industrial processes 62%.

The sources of the carbon component of the haze, and in particular the contribution of 'backyard burning' of garden and household refuse, have been investigated separately in a pilot study involving the SPCC and the Australian National University. In this study, samples of haze particulates were analysed for total carbon, carbon-13 and carbon-14. During its lifetime, when a plant continuously incorporates atmospheric carbon dioxide into its tissues by photosynthesis, the relative abundances of the carbon-12, carbon-13 and carbon-14 isotopes are in equilibrium, but when the plant dies the radioactive carbon-14 atoms decay and are not replaced from the atmosphere. Since the carbonaceous particulates arising from backyard burning are derived mainly from non-fossil fuels such as paper, cardboard and vegetation, they contain significant quantities of carbon-14, while particulates from the burning of fossil fuels, hundreds of millions of years old, contain none. Therefore, by utilising the carbon-isotope techniques developed for archaeological dating, it has been possible to estimate the relative contributions of refuse burning and fossil-fuel burning to the carbonaceous haze.

Photochemical smog in Sydney. These photographs were taken at 9am and 11am on a sunny day in February 1974 and illustrate the build-up in oxidant concentrations as hydro carbons and nitrogen oxides react in the atmosphere. Photos courtesy of the NSW State Pollution Control Commission.

The carbon-14 results from the pilot study showed that non-fossil sources are responsible for about 40% of the carbon in suspended particulates in the heart of the city, and about 55% at Lidcombe, where there is a mixture of industry and residences. Samples collected from Wahroonga and Loftus, representing bushland residential areas with virtually no industry, showed a 90% contribution from non-fossil sources on weekends and a 70% contribution on weekdays. Backyard burning

Norfolk Island pines damaged by surfactants in spray from offshore waters polluted by detergents, near the sewage outfall at Malabar. Photo courtesy of the NSW State Pollution Control Commission.



Centre and right, damage to rubber and vegetation caused by photochemical smog. Photos courtesy of the NSW State Pollution Control Commission.

is thus clearly a significant contributor to particulate air pollution in Sydney.

Photochemical smog

Photochemical smog is Sydney's worst air-pollution problem. In common with Los Angeles, Tokyo and other large cities around the world, Sydney has recorded episodes of high photochemical smog levels. Elevated levels have also been recorded in Melbourne, Adelaide and Wollongong/Port Kembla. The last case is mainly as a result of smog moving south from Sydney. Potential smog problems have been demonstrated for several other major Australian cities.

Photochemical smog consists of a mixture of secondary pollutants, sometimes referred to as 'oxidants', which form in the atmosphere, in the presence of sunlight, as a result of chemical reactions between nitrogen oxides and hydrocarbons.

On a typical weekday in 1976 some 635 tonnes of hydrocarbons were emitted into the Sydney atmosphere. Over 50% of these emissions were from motor vehicles, and motor vehicle support industries such as refineries, petroleum storage and transfer and motor vehicle painting contributed at least another 15%. Motor vehicles were also responsible for about 85% of the 170 tonnes of nitrogen oxides emitted into the Sydney atmosphere each day.

The pollutants in photochemical smog include ozone, nitrogen dioxide, nitric acid, peroxyacetyl nitrate (PAN), aldehydes and a wide range of other organic products, especially peroxides and ketones.

The chemical reactions giving rise to photochemical pollution are extremely numerous and complex, and the precise mechanisms for the formation of ozone and other oxidants are still not completely understood.

The production of high concentrations of oxidants depends on both the absolute and relative concentrations of reactive hydrocarbons and oxides of nitrogen, and also on the presence of suitable meteorological conditions—a temperature inversion, low wind speeds and adequate amounts of ultra-violet light. The fine, warm, sunny summer weather and basin-like topography of Sydney often provide just such conditions.

The worst smog in Sydney occurs in the central, southern and western areas of the city, a region occupied by more than two million people. Long-distance transport of photochemical smog downwind of Sydney has also been observed. On a typical high-smog day in Sydney, the polluted airmass first moves offshore within a westerly drainage flow and then returns with seabreezes early in the afternoon. These breezes carry the smog over the western and southwestern suburbs, to Campbelltown and down to Mittagong and beyond, and also appear to carry smog down the coastal zone south of Sydney to Wollongong and Port Kembla, where it is joined by additional air pollutants before continuing further south.

Effects on human health

The effects of photochemical smog on human health include headaches, irritation of the eyes and the mucous linings of the nose and throat, and impairment of lung functions, causing chest tightness, coughs and wheezing. The likelihood and severity of these effects depend on the concentration of the oxidants in the atmosphere and the sensitivity and activity of the individual; the respiratory effects are greater for people who are exercising or who have hyper-reactive airways, such as asthmatics. At sufficiently high concentrations the oxidants may trigger attacks in asthmatics. It has been suggested by some studies that ozone and other oxidants may lower human resistance to bacterial infection and accelerate the ageing process in living organisms.

Other effects of photochemical smog include damage to plants, with loss of crop yield, slowing of growth and/or death; deterioration of rubber and fabrics; a decrease in visibility and increase in glare caused by photochemically formed aerosol haze; and a general reduction in the feeling of 'well-being' of many people.

The concentration of ozone, the major constituent, is commonly used as an indicator of the severity of photochemical smog, although several other constituents are more toxic than ozone. The Australian National Health and Medical Research Council's long-

Public support for stronger air-pollution controls

A recent survey of public attitudes to air-pollution control has shown there is strong community support for stricter controls and greater public expenditure in this area.

The survey, based on 500 interviews in Sydney and a smaller number in Adelaide, was conducted by a leading market research company for the Australian Environment Council.

Only 11% of Sydney respondents to the survey thought the current cost of air-pollution control measures in Australia, $25 per person per year, was too much. On average, respondents in Sydney were prepared to spend $17 more per person per year to achieve cleaner air, equivalent to a 70% increase in expenditure on air-pollution control. Car owners were particularly willing to pay more, being prepared to increase their annual car costs by an average of $61 to help reduce air pollution.

The survey also indicated strong public support in Sydney for a number of specific anti-pollution measures:

- **Control of lead in petrol (supported by 86%)**
- **Tougher general air-pollution controls and fines (supported by 90%)**
- **Stricter and more effective controls on cars, such as annual checks of emission-control devices (supported by 79%), the introduction of stricter emission controls in NSW in January 1981 (67%), registration fee penalties for heavily polluting engines (72%) and smoke-control programmes for trucks and buses (96%)**
- **Use of lower-polluting fuels such as LPG (85%)**
- **Schemes to encourage bicycle riders (84%)**
- **Transit lanes for public transport and cars with several occupants (75%)**
- **Restrictions on car use in the inner-city area (73%)**
- **Computer-organised car pools (55%)**
- **'No-burn' days for incinerators (81%).**

Above, looking west from the Sydney city centre at the smog-blanketed western suburbs. Photo Trevern Dawes.

Left, inner city street canyons help to trap air pollutants such as carbon monoxide, lead and smoke. Photo courtesy of the NSW State Pollution Control Commission.

term goal for one-hour average ozone concentration, not to be exceeded on more than one day per year on a statistical basis, is 12 parts per hundred million (pphm).

Headaches, eye irritation and respiratory effects may be evident at concentrations of 15 to 25pphm, and attacks in sensitive asthmatics may be triggered when levels reach about 25pphm. Damage to some plants and materials occurs at concentrations of 10pphm and above.

Photochemical smog in Sydney first attracted public attention in the early 1970s. In the years 1975 to 1977, one-hour average ozone concentrations above 12pphm were recorded in the central, southern and western parts of Sydney on about 40 days each year. Since 1977 there has been a decline in ozone concentrations and the number of days on which 12pphm has been exceeded, but this decline has probably resulted mainly from meteorological factors, and an increase could well occur again in the future, as happened recently in California following several years of decline.

On high-smog days elevated ozone concentrations typically cover a quarter or more of the central, southern and western regions of Sydney for one to eight hours. There have been confirmed reports of damage to health, plants and materials in Sydney as a result of these concentrations.

Lead

Lead has long been recognised as a toxic chemical, with no beneficial effects on the health of human beings. When inhaled or ingested in sufficient quantities it can cause severe health damage and even death.

But in recent years there has been increasing concern about the effects of even low concentrations of lead on human health.

As a result, the health aspects of adding lead to petrol have come to the fore, since almost all the atmospheric lead in large Australian cities—about 800 tonnes in 1980 in Sydney alone—is derived from the burning of leaded petrol.

Children are more susceptible to lead than adults, and their developing nervous systems are more easily damaged. Recent studies in the United States, the United Kingdom and Australia have indicated a range of effects in children which can be associated with the observed accumulation of lead in their bodies, such as reduced intelligence, reduced ability to concentrate, an inclination to non-adaptive behaviour and hyperactivity. Pregnant women are another group with a greater than average susceptibility to the harmful effects of even low levels of lead.

Source of lead dispute

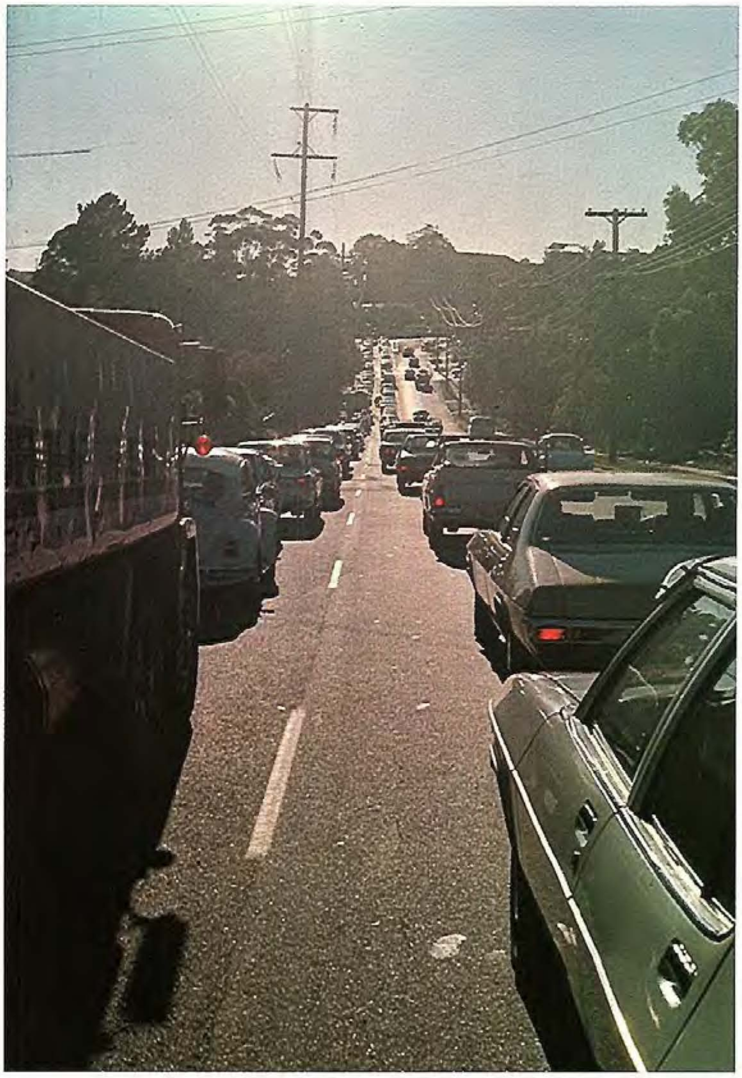
Lead can enter our bodies from the air we breathe, the food we eat, the water we drink and, particularly in the case of children, dust on articles which are handled or put in mouths. The relative significance of these various routes are difficult to determine, but in view of the high lead content of dust in urban areas the body burden of lead due to leaded petrol is likely to be noticeably greater than that due to respiration alone. The relative contributions to the total lead intake from naturally occurring lead in soils and from leaded petrol are the subject of much dispute, but recent isotopic studies by the CSIRO around Adelaide have found significant quantities of lead from leaded petrol in soils up to 50km from the city, much further than expected, and this lead has been less tightly bound in the soil than natural lead, suggesting a greater uptake by plants used for food.

The National Health and Medical Research Council has estimated that 20% of the total body lead burden can be contributed by lead in the air. The National Health and Medical Research Council (NHMRC) has also accepted a direct correlation between the levels of lead in the air and the levels of lead in our bodies. On this basis, it has recommended that the maximum permissible level of lead in air in the urban environment should be 1.5 micrograms per cubic metre ($\mu g/m^3$), averaged over three months.

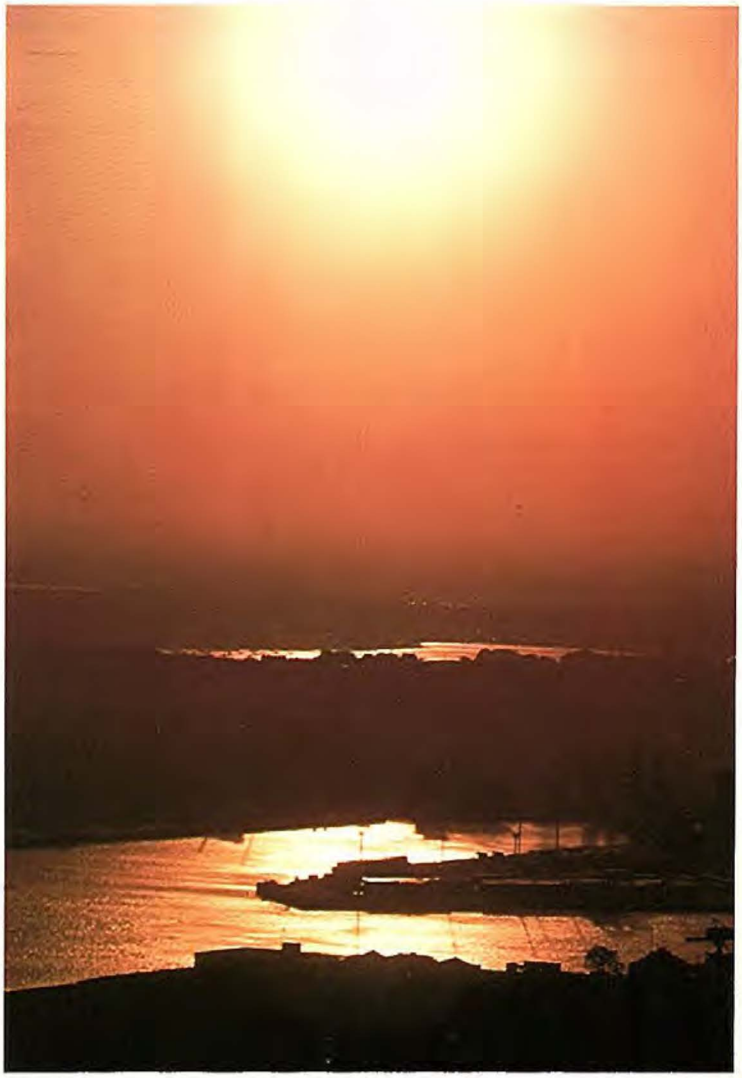
In 1980 the three-month average in central Sydney ranged between 1.9 and 3.2 $\mu g/m^3$, and the maximum recommended level was exceeded at all the SPCC's suburban monitoring sites during the winter months. Surveys at schools in Sydney also showed elevated lead levels, and three-month averages as high as 4.1, 3.1 and 8.3 $\mu g/m^3$ have been recorded at sites in Brisbane, Adelaide and Melbourne, respectively.

Carbon monoxide concentrations in Sydney areas with high traffic densities are frequently above the levels recommended by the World Health Organisation. In 1979, for example, the WHO's long-term goal of 10mg/m³ (eight-hour average) was exceeded on 284 days in central Sydney and 56 days in North Sydney. Over 90% of the 2200 tonnes of carbon monoxide emitted into Sydney's air each day is emitted from motor vehicles. High levels have also been recorded in other capital cities.

Coarse particulate fallout was the first air pollutant to attract attention in Australia, and dust deposition rates in Sydney fell substantially in the 1960s and early 1970s as a result of control programmes implemented at that



The cause, motor vehicles are one of the main contributors to the 'brown haze' experienced in Sydney, especially during the winter months. Photo courtesy of the NSW State Pollution Control Commission.



The effect, the sun burning through the pollution haze. Photo Trevern Dawes.

time. However, in recent years dust fallout levels in Sydney have shown some signs of a gradual increase, as have suspended particulate concentrations in the central city area, although the trends are uncertain and the levels are still below those of ten years ago.

Other pollutants routinely monitored by the SPCC in Sydney include acid gases (such as sulphur dioxide), copper, iron and cadmium, nitrogen oxide and hydrocarbons. Special studies are also being made of gaseous nitric acid, peroxyacetyl nitrate and sulphate concentrations.

In addition, specific air-pollution problems arise from some types of industrial premises in the Sydney region, such as ammonium chloride fume from galvanising works, ash from old inner-city power stations and odours from oil refineries, chemical works, rendering works and wastewater-treatment plants. Surfactants discharged to the ocean from sewer outfalls have damaged beach-front vegetation exposed to sea spray.

On a local level these specific air-pollution problems are often the major cause of concern for nearby residents. The pollution-complaints service operated by the SPCC is heavily utilised, and much 'unseen' work is done by SPCC inspectors in dealing with local dust, odour and fume problems.

Methods of control

As we have seen above, motor vehicles are responsible for almost all the lead and carbon monoxide, much of the photochemical smog and about one-fifth of the 'brown haze' in Sydney's air. It is therefore not surprising that New South Wales has taken the lead in Australia in controlling emissions from this source.

Detailed investigations of the causes, formation, movement and possible methods of control of photochemical smog in Sydney, involving multi-disciplinary teams from the SPCC, the CSIRO and the universities in a combined $1 million project known as the Sydney Oxidant Study, have shown that large reductions in hydrocarbon emissions are required if ozone levels are to be significantly reduced. The study showed that the control of hydrocarbons is more cost-effective than the control of nitrogen oxides in the Sydney situation.

Accordingly, hydrocarbon emissions from motor vehicles have been or will be reduced by eliminating crankcase emissions from new vehicles, by greatly reducing evaporative emissions from fuel systems, especially with new controls applying in New South Wales from January 1982, and by progressively reducing the permitted hydrocarbon exhaust emission. Exhaust emissions of carbon monoxide and nitrogen oxides have also been progressively reduced. New exhaust-emission standards applied in New South Wales since January 1981 are stricter than those in other states.

However, these moves have been counteracted by increasing vehicle populations, just as progressive reductions in the permitted lead content of petrol have been matched by increased petrol consumption. The breakthrough came early in 1981, with the agreement of the state and commonwealth governments that unleaded petrol will be introduced nationwide from July 1985. In an associated move, much tougher exhaust-emission standards, equivalent to those applying in the United States in 1975, will apply from January 1986.

These decisions, following strong pressure from the NSW government, which had announced its willingness to 'go it alone' if necessary, mean that a number of pollution and energy-conservation problems will be tackled simultaneously.

Lead concentrations in the atmosphere will be substantially reduced as unleaded petrol is used in more and more vehicles from 1985 (the use of leaded petrol in cars made after 1 January 1986 will be prohibited).

Hydrocarbon emissions will be greatly reduced, thus reducing the potential for photochemical smog formation.

Carbon monoxide emissions will also be greatly reduced.

Catalytic converters, which require the use of unleaded petrol, will be able to be used to control exhaust emissions, thus removing the need for engine-based exhaust-emission controls, which impose a fuel-consumption and performance penalty on current cars.

Particulate emissions from motor vehicles will be reduced by the use of catalytic converters, which US tests show as reducing particulates about 26 times in comparison with particulate emissions from non-catalyst cars using leaded petrol. Some reduction in brown haze can be expected to follow.

These reductions in vehicle emissions will be accompanied by improvements in vehicle fuel economy, a bonus of the use of catalytic converters, and reduced vehicle maintenance costs, because the removal of lead and lead scavengers from petrol will extend the life of spark plugs, engine oil, exhaust pipes and mufflers.

There will be a net crude oil saving, as the slight increases in refinery consumption when lead cannot be used to boost octane ratings will be more than offset by the improved fuel economy of motor vehicles.

Other measures to reduce motor vehicle emissions are underway in New South Wales, following recent amendments to the Clean Air Act. These include requirements for more durable emission controls, regulations on the servicing of these controls and stricter enforcement of new-vehicle compliance with the prescribed standards. Present quality-control for new vehicles' pollution controls is extremely poor; only 45% of new vehicles tested by the SPCC from January to June 1981 complied with all the NSW emission limits.

In addition, the SPCC has foreshadowed the possible introduction of particulate emission standards for diesel vehicles. There is considerable scope for improvement in this area at minimal cost.

Backyard burning is another significant cause of the 'brown haze' Sydney experiences. Photo courtesy of the NSW State Pollution Control Commission.

Hydrocarbon emissions from sources other than motor vehicles also need to be controlled before the photochemical smog problem can be beaten. There are a number of major stationary sources of hydrocarbons in the Sydney area, and the controls to be applied in these areas are:

1. **Storage and transfer of volatile organic liquids.** Following recent amendments to the Clean Air Act, regulations designed to reduce evaporative losses of petrol, crude oil and several major petrochemicals during their storage and handling are shortly to be introduced. These regulations will enforce measures such as the fitting of floating covers or roofs on storage tanks and the use of back-venting for road tankers delivering petrol to service stations. Evaporative emissions from these sources accounted for about 8% of hydrocarbon emissions in 1976.

2. **Chemical plants and oil refineries.** Emissions from vents, pump and pipe seals and accidents during the processing of crude oil and other hydrocarbons accounted for 8% of hydrocarbon emissions in Sydney in 1976. These emissions are being reduced by incorporating improved equipment in new plant, by retrofitting controls to existing plant and by tighter inspection programmes.

3. **Solvent emissions.** About one-quarter of Sydney's hydrocarbon emissions in 1976 resulted from the evaporation of solvents from paint and other surface coatings, printing ink, automotive refinishers, adhesives and sealants, automotive manufacturing, engineering and degreasing operations and dry cleaning. Recent rapid increases in the price of solvents have improved the economic attractiveness of control measures such as solvent recovery and re-use and the reformulation of coatings using water-borne, high-solids or solventless technology. Emissions from these sources appear to have fallen by about 15% between 1976 and 1980.

4. **Lawnmowers and backyard burning** account for about 4% of hydrocarbon emissions on weekends in Sydney. Voluntary restraint on predicted high-smog days can reduce their impact. Attempts are being made to reduce emissions from mowers, especially two-strokes.

Because only preliminary results are available from investigations of Sydney's brown haze, the precise control measures required for its control are not yet clear. However, apart from the motor-vehicle controls discussed above, two general approaches are evident.

First, since elemental carbon forms a relatively large component of the haze, it seems likely that emissions from fuel burning at stationary sources are major contributors. Although it has not yet been possible to precisely quantify this contribution, it appears that about half of all the brown haze is coming from industrial combustion.

Much can be done to improve industrial combustion without particularly expensive control measures and without any need to await the results of further research into the precise contributions of different sources to the haze. Attention to detail usually makes all the difference between dirty or 'sooty' burning and clean burning. It is not generally appreciated, for example, that oil-fired equipment can produce copious quantities of soot without emissions from the stack being visible. These emissions can be corrected by improved atomisation of fuel or possibly even by simple maintenance of the burner, often with immediate improvements in fuel consumption and costs.

Secondly, since backyard burning appears to contribute significantly to the carbon component of the haze, voluntary restraint on days when high air-pollution levels are forecast can be of assistance. The SPCC operates a daily pollution-forecasting service for the Sydney area, and appeals to the public to refrain from open burning are broadcast when meteorological conditions are likely to prevent good dispersion.

The future

Air-pollution problems as serious as Sydney's will not simply blow away or be solved overnight. Considerable research has been necessary, and more is required, to even begin to understand the complex factors influencing pollution levels in the region and to determine the most cost-effective means of control. Many of the control measures implemented so far have slowed the rate of increase rather than reversed the trend, but in some areas significant improvements have been made. In the crucial areas of photochemical smog and lead pollution a firm, effective course for control has now been established, and for brown haze the general approaches to control are now becoming clear.

This turn-around is perhaps best illustrated by a recent prediction by the SPCC, made firmly for the first time in its 1980-81 annual report, that even allowing for the developments now taking place, Sydney's air will be cleaner in the 1990s than it was in the 1970s. It would have been a very brave person indeed who would have made such a prediction ten years ago.

GETTING TO KNOW FUNNEL WEBS

Very few summers pass in Australia without some sensational headline news about funnel web spiders. No other venomous Australian, with the possible exception of the Taipan snake has gained so much publicity and remained so little understood. Substantial advances have recently been made in the development of an anti-venom which has saved lives. There can never be any reliable statistics on how many bites may have been avoided by simple safety measures, yet precautions based on knowledge of the animal can minimise the human risk of fatal encounters. Mike Gray, author of this article and arachnologist at the Australian Museum gives some valuable information about aspects of identification, behaviour and habitat which will usefully reinforce basic safety measures.

by Mike Gray

Male Sydney Funnel Web spider *Atrax robustus*; note the sharp spur on the second leg.

To the untrained observer the reliable identification of Funnel Web spiders can present problems. They lack easily observable features such as a characteristic abdominal colour pattern or obvious, unique structural modifications. In general terms Funnel Webs are large, black to reddish brown spiders with relatively hairless bodies, a smooth, shiny carapace covering the front part of the body and a pair of relatively long, pointed spinnerets projecting from the rear of the unpatterned abdomen; male spiders may have a projection or spur placed about halfway along the second leg. However, exceptions to this general picture are not uncommon. Colour may be much lighter, especially on the abdomen; the spinnerets may be rather short and not very obvious; body size can vary from 1.5 to 6 centimetres depending on the species concerned; and the spur on the male second leg varies in shape and in many species is not present. Photo J. Fields, Australian Museum.

Funnel Web Spiders first appeared in the scientific literature in 1873 under the generic name *Hadronyche*. A few years later, in 1877, the English arachnologist O. Pickard-Cambridge established the genus *Atrax* for a female spider from 'New Holland' which he called *Atrax robustus*. Since that time this species is now rather better known as the Sydney Funnel Web Spider. Since then the name *Atrax* has been generally used for all funnel web species. Only eight more species have been described since 1877. Further revisionary work at the Australian Museum has established the existence of twenty-five additional species. Just how venomous most of these new species are remains to be discovered.

The Funnel Web Spiders occur only in Australia and are largely restricted to the forests of the south eastern region of the continent. Most of the numerous species now recognised are ground dwellers but at least two species have taken to living in trees.

Funnel Webs can be subdivided into several structurally distinct groups of closely related species. These species groups are based largely upon differences in the structure of the sperm storage/mating organ on the male palp, the first and second legs of male spiders, the female internal genitalia, the spinnerets and various measurable or countable features on the cephalothorax (the front section of the body and legs).

Funnel Web Spiders are found most abundantly in the moist coastal and highland forests of south eastern Australia. In dryer conditions, such as occur on the western slopes of the Great Dividing Range, Funnel Web numbers fall away, their western limits coinciding roughly with those of open forest vegetation.

The southern limits of the genus are occupied by the Tasmanian Funnel Web Spider, *Atrax venenatus*, which is common in the eastern half of Tasmania. Only one other Tasmanian species is known, *A. pulvinator*, a rare species from the Hobart area.

The Funnel Web Spiders of Victoria are poorly known. So far eight species have been recorded from the eastern and central regions including *A. modestus*, common in the highlands just east of Melbourne, and A. *meridiana*, a species ranging from central Victoria into southern New South Wales. Interestingly, Funnel Webs appear to be absent from the wet temperate rain forests of the Otway Ranges south west of Melbourne. This corresponds with the absence from similar forests in western Tasmania.

Between the Grampian Range in western Victoria and Mt Lofty–Flinders Ranges in South Australia, there seems to be a major gap in Funnel Web distribution. This gap coincides with the dryer, more open heath/woodland vegetation associations of the southern Murray Basin.

The Funnel Webs reappear in South Australia as an isolated group of species occupying the Mt Lofty and southern Flinders Ranges and the southern Eyre Peninsula. Their presence on the Eyre Peninsula is interesting because it raises the possibility that the group could have spread further west when climatic conditions across southern Australia were wetter than they are now. If this did happen another isolated group of Funnel Web spiders may yet await discovery in south western Australia.

The elevated, dissected eastern third of New South Wales contains the majority of the Funnel Web species so far recorded.

The Sydney Funnel Web Spider, *A. robustus*, occupies the central coastal region of New South Wales from Newcastle in the north to Nowra in the south and also extends west as far as Lithgow in the Blue Mountains. In the Sydney region the spider is most common on the dissected uplands of the southern Hornsby Plateau (north of the Parramatta River), the Woronora Plateau (south of the Georges River) and in the lower Blue Mountains to the west. Forested hillside and gully habitats are preferred to the dryer ridge-tops in these areas. The central and western regions of Sydney are placed in the lower, relatively flat and open country of the Cumberland Basin where the lack of suitable habitat makes Funnel Webs less common.

The development of suburban Sydney in relation to the local basin and upland topography explains the once commonly held belief that funnel webs were confined to the northern suburban areas. This impression

Distribution of Funnel Web spiders is shown in the map at the top of this column. On the right a close up of a treedweller, *A. cerberea*. Above centre, *A. versutus*, a common ground dweller, and last the largest of the Funnel Web spiders, *A. formidabilis*. Photos: H. McLennan, G. Millen, M. Gray, Australian Museum.

arose simply because the 'North Shore' area was the first upland region around the Sydney Basin to be significantly populated so that almost all of the early funnel web collections came from there. With the much later expansion of population in southern and western areas the common occurrence of funnel webs in other upland habitats is now more generally appreciated.

Two species closely related to the Sydney Funnel Web occur in southern New South Wales. One is coastal, and extends down into the Gippsland area of Victoria. The other is a highland species, whose distribution includes the Canberra area, skirts around the Snowy Mountains and extends south into the eastern highlands of Victoria.

The high country has its own Alpine Funnel Web Spider, a species which is closely related to the Tasmanian Funnel Web, *A. venenatus*. The Alpine Funnel Web is found in the Brindabilla-Bimberi Ranges and the Snowy Mountains and probably extends into the Victorian alpine regions. Dead male spiders are often seen lying in the snow in these areas.

The two species of tree Funnel Web spiders are widely distributed, one south, the other mainly north of the Hunter River. The southern tree Funnel Web, *A. cerberea*, is common in southern coastal and highland regions. It is closely related to the Blue Mountains Funnel Web Spider, *A versutus*, a common ground dwelling species in the highlands to the west and south of Sydney.

The Northern Tree Funnel Web Spider, *A. formidabilis*, is found on the wet, heavily forested slopes of the Great Dividing Range from the Bunya Mountains of southern Queensland to the Barrington Tops region in New South Wales. However, the distribution of this species, the largest of the Funnel Web spiders, was once more extensive and an isolated southern population still persists in the forests of the Illawarra region south of Wollongong.

In the northern highlands different Funnel Web species are associated with the mountain blocks formed by the Barrington Tops and New England plateau regions. In coastal areas species clearly related to the Barrington Funnel Web stretch up the coast to the Clarence River area. Beyond this a distinctive species, *A validus*, the Lismore Funnel Web Spider, occupies the area around Lismore and north to the McPherson Range straddling the Queensland border.

The western slopes and outliers of the Great Dividing Range have their own suite of Funnel Web Spiders, often related to adjacent highland species. The Mount Kaputar Funnel Web and the Warrumbungles Funnel Web (whose range stretches southward almost to Orange) are both examples of the latter. The large, black South West Slopes Funnel Web occupies the western slopes and tablelands from Bathurst to the Riverina.

The northern distribution limits of the Funnel Web spiders seem to be reached in the coastal ranges south of Gladstone in south east Queensland. This roughly corresponds with the western trend of the Great Dividing Range into the dryer inland. The main species in south-east Queensland is *A. infensus*, the Toowoomba Funnel Web Spider, which is particularly common in the highlands west of Brisbane.

Despite a considerable amount of collecting no funnel web specimens have been taken north of the limits outlined above since the early part of the century. While more collecting needs to be done this does raise the possibility that the few, old, northern Funnel Web records could simply represent mistakes in recording collecting localities.

Funnel Web Spiders are moisture dependent animals, a fact borne out both by their distribution pattern and the places where their webs are found. The retreats of many species are often well hidden in or under logs and rocks, at the bases of stumps or thick, tussocky vegetation and, naturally enough, in equivalent garden habitats created by man. Such sheltered places provide the fairly stable high humidity, low temperature environment preferred by these spiders.

Deep holes or clefts in trees provide the same sort of conditions for tree dwelling Funnel Webs.

Even in quite open conditions, such as paddocks or roadside verges, remnant populations of funnel webs can survive provided sufficient ground cover (such as rotting logs or boulders) is left to provide shelter for both the

Nests, or retreats of Funnel Web spiders have several features in common. From top left: a ground dweller's nest entrance, clearly portraying 'trip lines'; a typical long silk tube which gives access to the underground burrow; a tree-dweller's nest in section, the spider is visible at the base of the burrow. Above *A. formidabilis* about to seize a bush cockroach—tasty snack for lunch! Photos: M. Gray.

spider and its food supply. Some species on the western slopes and southern tablelands can be found in naturally open habitats. Here other factors such as ground slope, shading and burrow depth ensure a moderate retreat microclimate.

The most common type of Funnel Web Spider retreat consists of a silk tube, built in a cavity under a log or rock, with one or two entrances (occasionally several) guyed out by coarse, irregular trip lines running over the adjacent ground litter. A burrow of variable depth descends in the ground from the back of the tube.

Tree dwelling Funnel Webs have basically similar retreats. The surface entrance(s) and tube, often well disguised with small pieces of bark, are placed on the bark surface. A burrow descends from the tube into the wood via a fault in the trunk where a branch has broken off or a boring insect has emerged. The Northern Tree Funnel Web, which is particularly common in rainforests habitats, is often found in retreats as much as 15 metres above the ground. Its counterpart, the Southern Tree Funnel Web is most common in open forest habitats characterised by roughbarked trees such as *Banksia*, *Casuarina* (she-oak), *Melaleuca* (paperbark), and some eucalypts.

A few species build distinctive retreats which differ considerably from the pattern outlined above. For example, a small species from the southern tablelands makes an open, vertical, flask shaped burrow with a few trip lines radiating out from the rim.

The presence of surface trip lines is characteristic of almost all types of funnel web retreats; if they are not present one can usually say that the retreat is not that of a Funnel Web. One notable exception to this involves the isolated group of Funnel Webs from South Australia. These spiders build vertical burrows in dry open forest habitats, whose small, hooded entrances are well hidden among the ground litter. Instead of the usual simple burrow, about two thirds of the way down there is a thick trapdoor which opens into a small rounded side chamber. None of the other Funnel Web Spiders or their relatives are known to make trapdoors of any sort (an activity usually associated with the trapdoor spiders of the families Ctenizidae and Migidae). The South Australian Funnel Webs probably use their side chambers to escape from predators (such as scorpions, centipedes, wasps); as a moulting chamber where the spider can rest undisturbed after casting its skin; and as a brood chamber for the eggs and young.

In order to grow Funnel Webs must moult (cast off their rigid, external cuticle and replace it with a larger one formed underneath) periodically. Like other mygalomorph spiders the female Funnel Webs continue to moult throughout life, though growth is very slow after reaching maturity.

Funnel Web Spiders are long lived (females living as long as eight years or more) and take several years to reach maturity. Specimens reared by Mrs V. Gregg, a Research Associate of the Museum, suggest that it takes three to four years for males, and four to five years for females, to mature. The males have a much shorter life span than females for, once mature, they have only six to nine months to live. Most males mature during late spring to summer and leave their burrows to become night wanderers with little interest in feeding, simply searching for a female with which to mate. This behavioural change is reflected in the differences of body build between the sexes. Mature males have longer legs and smaller bodies adapted for mobility; females have shorter legs and heavier bodies suited to a sedentary life and egg production. Male activity is greatest during the summer-autumn period and it is in this period that almost all human envenomations occur.

Funnel Webs feed on a variety of ground and bark dwelling invertebrates, such as beetles, ants, cockroaches, millipedes, other spiders, slaters and snails. They will also take small vertebrates such as frogs and lizards. Hunting is done mainly at night, the spider waiting motionless just inside an entrance, its front legs projecting to feel any disturbance of the trip lines. When a beetle or other prey walks into a trip line the spider charges out to it, seizes the prey in its front legs and bites it. The prey is then carried back into the entrance tube and consumed. A well fed spider can store a large amount of food in the side branches of the gut. This can allow it to go for long periods without food.

After locating the web of a female, the male establishes himself as a potential mate by a series of approaches and retreats to and

from the female sitting at the burrow entrance. After some mutual tapping with front legs and palps the female adopts a defensive pose, the front legs raised, facing the male. The male braces himself against the female, using his upraised, spiny, often spurred, front two pairs of legs to lift and steady her. In this position he inserts his sperm charged palps (the spine-like sperm storage/mating organ is at the tip) into her opening near the front of the underside of the abdomen. The male usually survives these encounters if the female is receptive and is, in any case, fairly fast moving and adept at defending himself.

Some 80-250 eggs are laid in a pillow shaped, silken egg sac which the female guards near the bottom of her burrow. Egg sacs are produced during spring and summer. The spiderlings mostly disperse in late summer and autumn, only a few surviving to become adults.

Adult spiders seem to have few important direct predators. Occasional victims of centipedes, scorpions, bandicoots and birds, funnel webs suffer greater mortality from the common afflictions of all ground dwelling spiders—attack by mermethid worms, mites and sometimes fungus.

The erroneously held belief in the jumping ability of Funnel Web spiders probably stems from the rapid, jerky, sometimes bouncy movements of the male spiders and their tendency to rear up into the strike position at the least provocation. In fact, Funnel Web spiders can only manage a short spring of 2-3cm and even this is rare.

Funnel Webs are caught by the experienced collector by coaxing them more of less forcibly into small glass vials. However, an

Part of the mating ritual (top left) described in the text on this page. Scanning electron micrographs of the palp of two species of Funnel Web spiders. Sperm secreted from the abdomen onto a small web is taken up into the mating organ and stored inside the bulb-like part pictured on the far left. During mating the shaft is inserted into the female genital opening on the abdomen and the sperm ejected via a pore near the tip (enlarged) pictured left. Photo M. Gray and M. McGrouther.

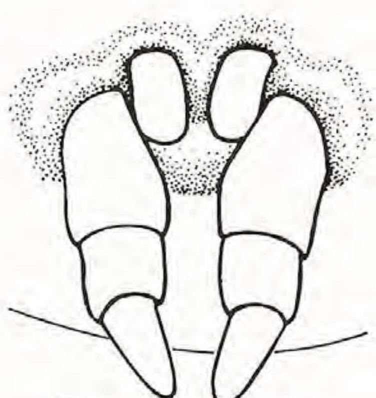
easy and perhaps safer method simply involves placing the neck of a jar over the spider, slipping a piece of paper under both jar and spider, folding the sides of paper back against the jar sides and then inverting the lot, keeping the fingers clear of the neck area, and allowing the spider to fall safely to the bottom of the jar.

Knowledge of funnel web spider venoms is confined almost entirely to the venom of the Sydney funnel web spider, the only species known to have caused human deaths. Thirteen deaths have been recorded since the first verified Funnel Web fatality in 1927 (eleven from the Sydney region, one each from the Nowra and Gosford regions). This is a very small number compared with the size of the human population involved—one's chances of being dangerously envenomated are obviously very small indeed. Many, probably most, Funnel Web bites result in minor symptoms only.

Three other species are known to be capable of causing severe envenomation. These are the Blue Mountains Funnel Web and the Northern and Southern Tree Funnel Web Spiders.

In all fatal cases where the sex of the spider was determined, male spiders were the culprits. The reason for this is twofold. Firstly, the venom of the male Sydney Funnel Web Spider is four to six times more toxic than that of the female; secondly, because of their wandering behaviour, male spiders are more likely to be encountered by humans. Female spiders have only occasionally been involved in cases of serious envenomation, juvenile spiders never.

The venom gland in the base of the funnel web jaw is under muscular control and is con-



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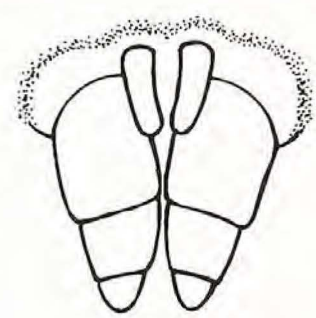

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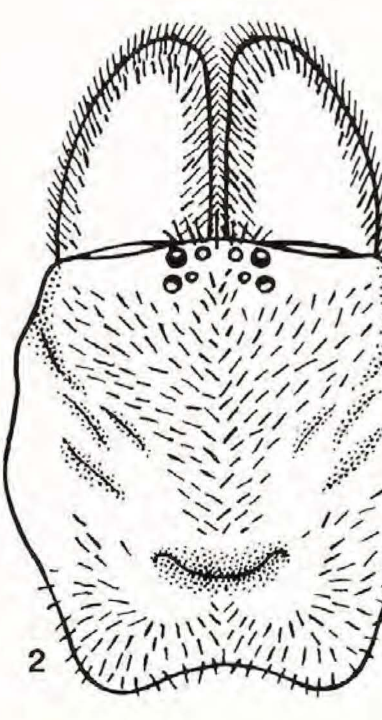

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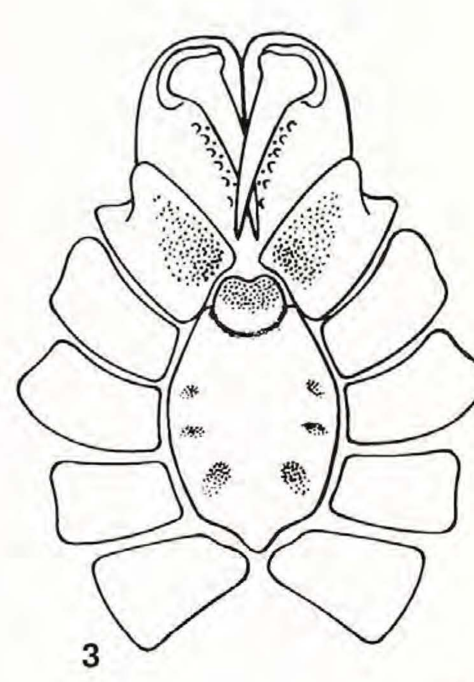

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Top right, Tree Funnel Web spider, *A. cerberea*, retreat in paper bark tree at Wamberal on the central coast of NSW.

Top centre, a gravid female, *A. versutus*, in retreat in a log. Photos M. Gray.

Points to be looked for in making a positive identification of a Funnel Web spider are the three features noted in the diagrams:
1a There are four spinnerets (silk spinning organs); the terminal segments of the longest spinnerets are always appreciably longer than wide.
1b Trapdoor spider spinneret-terminal segments are quite short in comparison.
2 The fovea, a pit-like depression behind the middle of the carapace, is usually concave towards the front.
3 The labium, a small plate on the ventral surface immediately behind the fangs, has many short, peg-like spines (over 40) on its surface.

Ready to strike! (far left) Funnel Web fangs may be up to 7mm long and in order to strike the spider must rear up and allow the fangs to hinge downwards. The venom gland (left) is muscularly controlled.

nected by a slender duct to an opening just above the fang tip. The fangs may be up to seven millimetres in length. To strike, the funnel web, like the trapdoor spiders, must rear the front part of its body up so that the fangs can hinge open downwards. Venom may appear at the fang tip prior to the strike, which may be repeated several times.

A curious feature of funnel web venom is that it only severely effects primates (man and monkeys), while other mammals, such as dogs, cats and rabbits, seem relatively immune.

The venom contains a neurotoxin which affects nerve fibre membrane function to cause the widespread release of the neurotransmitter chemical acetylcholine throughout the autonomic ('involuntary') nervous system and at motor nerve endings innervating the skeletal muscles. The resultant sustained stimulation of various target organs produces the characteristic features commonly seen in cases of severe envenomation.

The bite itself often causes considerable local pain because of tissue damage and the acidity of the venom. More general effects can develop within ten minutes of being bitten. These include nausea and vomiting, abdominal pain, sweating, salivation, lachrymation, shortness of breath associated with the secretion of fluid into the lungs, increased blood pressure and intra-cranial pressure, muscle twitching and loss of consciousness. Death may result from asphyxia or from a late onset of declining blood pressure leading to lung and heart failure.

Small children have generally been more at risk because of their smaller body volume and deaths have been recorded 15-90 minutes after a bite. Adults have died 30 hours or more after being bitten.

Until recently this daunting range of effects has had to be combated with a variety of symptomatic intensive care treatments, often highly successful, occasionally not. However, recently this situation has changed radically because of the successful introduction of an antivenom developed at the Commonwealth Serum Laboratories in Melbourne. This is undergoing proving trials in several hospitals in the Sydney-Gosford region. The patients so far treated with it have made remarkable recoveries with negligible side effects. The antivenom may also prove effective in cases of envenomation by Funnel Web species other than the Sydney Funnel Web Spider.

The history of the search for an effective antivenom has had many problems stemming largely from the complexity of the venom and the properties of its toxic component, atraxotoxin. One rather unexpected problem was that of atraxotoxin becoming attached to the glassware used in handling the venom and so being lost. It proved necessary to develop both specific assay techniques using newly born mice to test venom toxicity and neutralization and new separation procedures to allow concentration of the purified antivenom formed in the serum of rabbits immunized with the venom of male Sydney funnel web spiders. The recognition of an envenomation syndrome in monkeys very similar to that seen in humans provided an excellent means of testing the effectiveness of the antivenom with a view to human use.

Hopefully, the development of an antivenom means that Funnel Web envenomation will cease to be an occasionally severe medical problem, in much the same way as the medical problem posed by Red Back Spider bite declined with the arrival of an antivenom in 1957.

Despite this, it should be remembered that effective first aid is still of importance where a funnel web bite on a limb is suspected. Because it now seems that most of the transfer of venom from the superficial site of the bite into the general circulation is via the surface lymphatic system the recommended first aid technique is the application of a firm, broad constrictive bandage (not a tight tourniquet). Elastic or crepe bandages or strips of torn up towelling or clothing can be used to bind the limb.

Of course, it is best not to get bitten at all and an awareness of some basic features of funnel web behaviour and distribution, plus a few precautionary measures, can further reduce the possibility. The factor of most significance is the pattern of male wandering activity between December and June with a peak in the January-March period. It should also be remembered that wandering by both male and female spiders may occur after the following events:

1. *heavy rainfall* resulting in flooding of the spider's retreat.
2. *excavation works* causing disturbance of burrow sites such as swimming pool construction.
3. *pesticide spraying*—note that there is no proven pesticide that will get rid of funnel web spiders in their natural habitat. Their sheltered burrows provide considerable protection from the spray and once this dries it is ineffective against spiders. In addition, the wandering habits of the male spiders make it impossible to guarantee eradication. After spraying, mildly affected spiders, both males and females, can become highly excitable and aggressive and wander randomly, increasing the chances of an encounter with man. If spraying is done at all it should be concentrated only on areas known to harbour funnel webs and only short term residual sprays should be used. Blanket spraying of gardens is unnecessary and undesirable; besides their destructive effects on harmless, often useful, garden animals, the potentially deleterious effects of pesticides on domestic pets and young children should be kept in mind.

Householders are most likely to come into contact with wandering spiders which enter and become trapped inside houses, garages, laundries, garden sheds etc (note that these moisture dependent spiders cannot survive long in such relatively dry environments). Entry via doors can be stopped by fitting draught strips to eliminate gaps under doors, particularly those set right on ground level. Raised foundations are a good deterrent to funnel web entry. However, funnel webs are capable of climbing rough textured external walls and gaining entry via windows—fly wiring will prevent this. Clothing and bedding should be kept off ground level floors including those of garages and laundries. Campers should not leave clothing and shoes lying on the ground overnight and should check their gear each morning; a floored tent is also a good idea. Don't walk about barefoot at night. In the yard a general clean-up can be useful in eliminating possible web sites; for example, waste timber, bricks, rock-piles, galvanised iron etc left lying on the ground. Gloves may be worn while gardening. In-ground swimming pools should be inspected as wandering funnel web spiders may fall into them and can survive several hours immersion in water.

In its short relationship with Europeans, the funnel web has made a considerable impression upon the residents of the Sydney region. It would be interesting to know whether the Aboriginal people had any particular knowledge of these spiders. However, without the seasonal reinforcement provided by media reporting and the advertising of the pest control industry it seems unlikely that their attitudes would have been quite as fearful and misinformed as ours.

IN REVIEW

The Spectre of Truganini **by Bernard Smith, The Australian Broadcasting Commission, 1981, 56 pages, $2.95.**

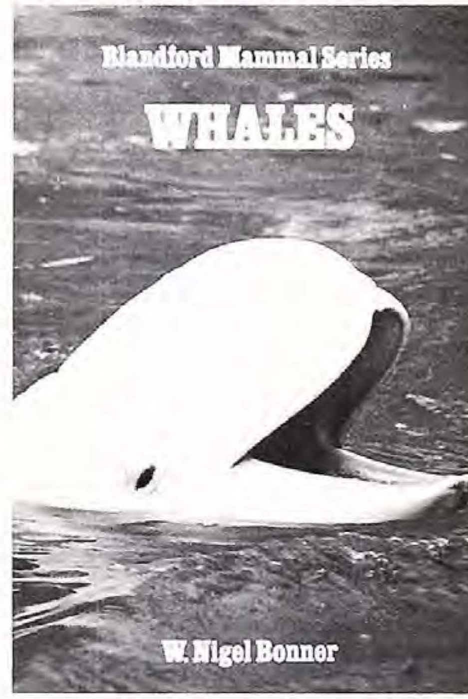
Over recent years, an increasing number of writers have drawn attention to the plight of Aborigines in Australian society and to the sorrowful record of events that led to the alienation of many Aboriginal people. Professor Bernard Smith, a reknowned authority on the history of European art in the Australian and Pacific region, sought to further illuminate the topic of black and white relationships in his 1980 series of Boyer Lectures, recently published in book form by the Australian Broadcasting Commission.

Where Professor Smith speaks from the wealth of his scholarship in the literary and visual arts, he is indeed illuminating, but too often he resorts to simplistic emotional appeal, to what he seems to consider as self-evident truths and to broad generalisations involving a wide range of subjects on which he is not particularly well versed. The result being a patchy, unconnected series of statements which is most disappointing. Professor Smith's main thesis seems to be that the development of Australian culture has withered on the vine and lacks any firm ethical basis because of a 'guilty awareness' felt by whites due to their history of shameful treatment of the Aborigines, symbolised by *The Spectre of Truganini*. Despite the heartfelt concern for Aboriginal and white relationships that Bernard Smith is so obviously voicing, this argument simply lacks credibility. Assuming 'culture' is defined in reasonably broad terms, as it is by anthropologists, I cannot imagine anything like a general feeling of guilt among non-aboriginal Australians regarding their history of colonisation of the continent.

They should be more concerned than they are about deprivations suffered by present day Aborigines and perhaps this is the real message that Professor Smith is trying, tortuously, to convey. But rather than guilt, I would expect ignorance and apathy to emerge as the most common attitudes, with concern, perhaps even guilty awareness on occasion, being felt by a minority group made up mainly of academics, churchmen, social workers and more enlightened members of the public.

Despite hopes expressed in the last chapter for a 'cultural convergence', Bernard Smith's book is a gloomy chronicle of events. I would like to have seen it concluded on a much more positive note, but, like a number of social histories written today, it is mainly an exercise in self-vilification that will contribute little to a more harmonious relationship between the two cultures.— *R.J. Lampert, Curator of Anthropology, the Australian Museum.*

Whales **by W. Nigel Bonner, Blandford Mammal Series, Blandford Press Ltd, Dorset, UK 1980, 278 pages, $34.50.**



Probably no other animal has experienced so rapid a rise to fame as the whale. Recent years have seen public interest and concern for these mammals reach an unprecedented high. So high, in fact, that in 1978 it moved the Federal Government to appoint an independent inquiry to examine Australia's role in the whaling industry.

As a group the whales and dolphins, or Cetacea as they are collectively called, number about nine families and include approximately 80 species. While not a particularly large nor well understood group, whales for a variety of reasons (not the least of which has been their plight at the hands of the whaling industry and the controversy surrounding their intelligence) have constantly attracted and maintained the attention of the public at large.

Inevitably whales' popularity and the curiosity they invoke has resulted in a flood of publications dealing with them. Alas, not all have been good. These publications have varied in quality from adventurous accounts of contact with the animals described with superlative Melvillian epithets such as 'Leviathans' and 'Mighty Monarchs' to catalogue-type descriptions often backed up with many fine photographs or to self-professed celebrations of the uniqueness of whales.

However, while many such publications are fine for the purposes for which they were intended, the critical reader will find precious few that fulfil the very real need for a general reference which simply and objectively attempts to document the whale as a living, functioning (and mortal) organism.

Bonner has attempted an integrated approach to the subject incorporating the simple structure and function of the animal with some of the more popular areas of interest, notably the whaling industry, its form, history and implications.

Essentially the book is divided into two parts, the first consisting of eight chapters each dealing with a particular aspect of Cetacean biology. Special attention should be directed to the first chapter entitled 'The Cetacea and their Environment', which is a particularly lucid and flowing expose of the mechanics of being a whale.

On the much harangued question of whale intelligence, Bonner takes a cautious and honest approach, qualifying his own belief that Cetaceans are not 'intelligent' by acknowledging the possibility of higher mental capabilities. ("On the other hand" he says "the large size of the brain and its highly developed cortex, seem to me to indicate the possibility of higher mental functions"). On this point a little more discussion of the controversy surrounding the brainsize/intelligence connection, would be welcome.

In the chapter on reproduction and development, Bonner attempts to rationalise various accounts of the epimeletic or 'caring' behaviour of Cetaceans that are often too readily interpreted as demonstrating a 'sense of compassion'. Some of the more vehement pro-whale enthusiasts may find his approach a little difficult to swallow, but, nevertheless, thought provoking.

Although it could be readily dismissed as a convergence resulting from the specialised nature of the subject, this section strongly reflects (perhaps uncomfortably so) a previous (1978) publication by L. Harrison Matthews, and it is difficult to avoid making comparisons. Bonner, however, extends his treatment in the second part.

In the second part of the book Bonner briefly chronicles the history of man's relationship with whales, an account which is necessarily dominated by the history of whaling. In six chapters, each of which is devoted to a particular phase of whaling history, he documents the history of the whaling industry from man's earliest contact with the animals and the early coastal fisheries for small whales, through the development of pelagic whaling and the industry in its present form culminating in a consideration of the implications for whales, of current and future management procedures and a plea for the rational use of marine resources.

An adequate helping of good line drawings complements the text but unfortunately the same cannot be said of the photographic plates (of which there are only 14 in the entire volume) the quality of which is far from consistent with the text's standard. Although some of the diagnostic characteristics are visible, the partially flensed carcass of the Fin Whale in plate six is hardly an ideal representation of the animal described in the text. The same applies for the badly decaying Pilot Whale in plate eight and the Southern Right Whale that appears as a dark shapeless mass, in a configuration that could be confusing to the uninitiated, in plate ten. At the very least some explanatory captions would be a welcome addition.

On the subject of whale stranding, possibly one of the greatest sources of curiosity among laymen and certainly one of the most popularized aspects of Cetacean biology, Bonner's treatment is conspicuously cursory. Considering the attention that this phenomenon has attracted in recent years, both academically and otherwise, a more detailed discussion of some of the theories (of which there are many) concerning the causes and consequences of strandings, would seem appropriate.

Bonner's treatment of whale migration (approximately two and a half pages in chapter seven) also leaves something to be desired. Together with strandings this aspect of Cetacean biology is probably the most obvious to the general public and is thus likely to be of particular interest to the general reader.

Despite the relatively inadequate coverage of whale stranding and migration the book will be of great interest to the general reader as a whole, answering most of the common questions such as, can a whale smell?, do they have hair?, how does a whale with no teeth sever the umbilicus?. The detail and substantial reference list render *Whales* by W. Nigel Bonner a most useful reference for students and the practising biologist especially those whose interest may lie in a field other than mammals. — ***John Hoey, Mammal Department, the Australian Museum.***

Australian Mammals by Jenny Pollak, Collins, Sydney, 1980, 32 pages, $8.95.

This unpretentious little volume should appeal widely to young readers, from five to eleven years of age, and to their parents. Fundamentally a picture-book it contains just enough information to provide a general background to the animals depicted. Children seeking more detailed information for school projects would need to refer to the more advanced texts that are available. They could well feel inspired to do so once they see the charming black and white pen drawings which are the reason for the book's existence.

The illustrations are decorative, without being coy, and sufficiently didactic to pass muster in a junior text-book. They provide a refreshing change from the over-simplified style of drawing that has dogged juvenile literature in recent decades. At the same time, they possess a little of the quality of those nineteenth century illustrations which, although sometimes fanciful and, on occasions, grossly inaccurate, managed to convey a sense of realism in whatever they depicted.

Jenny Pollak's drawings are composed of thousands of fine lines, produced with a very fine nibbed technical pen. This creates effects that are characteristic of etching, a subject she studied at the Byam Shaw School of Drawing and Painting in London. Although this technique is both elaborate and time-consuming, the work retains its freshness and its visual impact is crisp and immediate.

The only quarrel with the young artist is that her drawings look as though the animals were copied from photographs rather than from sketches of animals observed in the wild. Most of them appear in the somewhat frozen attitudes one associates with photography which is used primarily as a recording medium. The nocturnal eastern quoll is a prime example. Anyone who has used a flash-equipped camera in the field at night will understand why. While it no doubt assisted the artist to define the details of her subject the lighting is far too direct and its source too low and too close to be mistaken for natural illumination. Highlights and hard shadows, even the pin-point flash reflected from the quoll's eye, have been meticulously reproduced. This all suggests naive assumption on the part of the artist, a kind of "surely-no-one-else-will-notice" attitude towards her particular craft. Given the nature of the book, however, it probably does not matter very much. Certainly, I do not mean to decry the artist's abilities or the intrinsic elegance of her technique. In fact, I should very much like to see it developed further and applied to animals drawn from life.

The text is notable for its brevity and rather randomly selected snippets of information, the acknowledged sources being Gordon Lyne's *Marsupials and Monotremes of Australia* and the perennially popular *Furred Animals of Australia* by Ellis Troughton. Unfortunately, it lacks the consistency of information that could have been provided by someone more familiar with the subject than its artist/author. My twelve-year-old daughter, herself no expert with the written word, was more bothered by inconsistencies of language, finding fault with both style and context. Despite its faults, however, the text is easy to read and will be found adequate for children in infant and lower-primary school grades.

Parents who are aware that learning stimuli derived from pictorial representation are not inextricably linked with light colours and bold outlines, will find this book handy for conveying simple information, about some of Australia's unique mammals, to pre-schoolers and the kindergarten set. Teachers of young

children may also consider it a useful addition to the school library. After all, the pictures are delightful.

On a final note: the foreword, kindly supplied by the ubiquitous Vincent Serventy, is clear and concise, without being condescending towards its juvenile readers, and provides a well-written introduction to the subject matter which follows it. Something of the latest demagogue emerges through his final exhortation:

"Above all it is the duty of Australians to conserve this rich diversity among our mammals so that future generations will be able to enjoy them, as we do today."

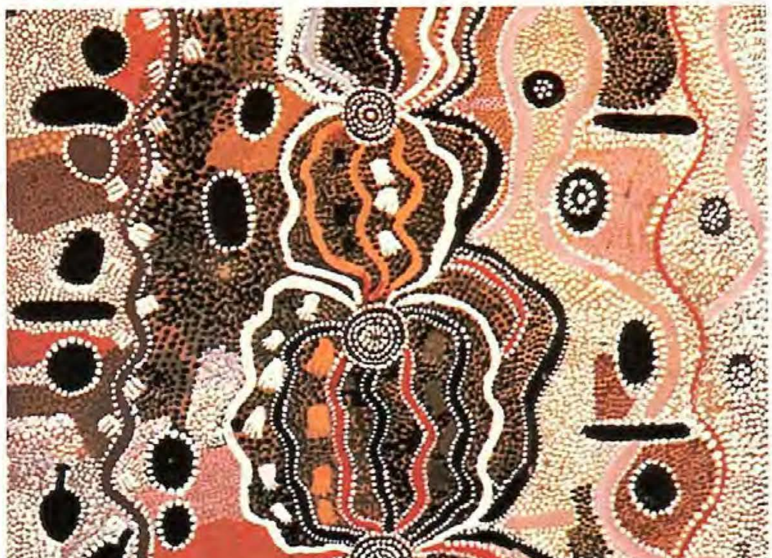
Fair enough. We are at least spared the 'Dear Boys and Girls' approach of some avuncular politician.—*Kingsley Gregg, Senior Artist, The Australian Museum.*

Search for the Tasmanian Tiger **by Q. Beresford and G. Bailey, Blubber Head Press, Hobart, 1981, Paperback, 54 pages, $8.95.**

Much confusion surrounds the fate of the Thylacine. The authors, respectively a graduate student in history and a journalist, have brought together a largely uncritical compendium of its history and mythology and, after larding it with speculation, leave readers 'to reach their own conclusions'. There is some outright nonsense such as the claim that the Thylacine was 'primarily a blood feeder, sucking from the jugular vein of its kill' but the reader with some knowledge of mammalogy can glean a proportion of wheat from the chaff, including the fact that the last Thylacine of which we have any definite knowledge died in the Beaumaris Zoo, Hobart, on 7 September 1936 and not (as many of us had been led to believe) two or three years earlier. There are a number of illustrations which have not been included in previous books.—*Ronald Strahan, Research Fellow, the Australian Museum.*

'ABORIGINAL AUSTRALIA'

by Roland Hughes



Entitled 'Children's Water Dreaming with Possum Story' this piece is acrylic on hardboard and is painted by Old Mick Tjakamara, from the Anmatjira Aranda Group, Northern Territory. The Water Dreaming is the rainmaking ritual. In the painting, the white lines of water cascade from one circular water hole to the next. Tracks of a boy and a possum are shown as they look for food in the creek bed.

A mourning ring from the Tiwi Group of Aborigines on Melville and Bathurst Islands, Northern Territory. It is made from ochre, abrus seeds, feathers and human hair string on bark.

"At the beginning of the world the Dreamtime Spirit Beings wandered the earth shaping the landscape", and the dawn of Aboriginal life evolved. So begins *Aboriginal Australia*, the largest exhibition of Aboriginal art ever mounted. Twin audio visual screens project the images as a commentary takes the visitor on a ten minute tour of the art and culture of one of the most ancient races of people on earth.

Two years to prepare

Opened on 20th October at the Australian Museum by the NSW Premier, Mr Neville Wran, *Aboriginal Australia* displays over 320 pieces reflecting Aboriginal traditions, philosophies and culture. Born from discussions between the Aboriginal Arts Board of the Australia Council, the National Gallery of Victoria and the Australian Gallery Directors Council, *Aboriginal Australia* has taken two years to prepare.

Divided into four sections—The Origins, The Art of Temperate South-East Australia, The Art of the Desert and The Art of Northern Australia—this unique exhibit consists of bark paintings, stunning acrylics on hardboard, a vast array of carvings, boomerangs, shields, clubs, spears, carved trees, message sticks, etc.

Aboriginal art is particularly interesting as it evolves from the representation of spiritual beliefs. As the Spirit Beings journeyed across Australia during those early times ". . . a resting place might become a rock or where they dug for water might become a permanent water hole. Part of their bodies might become hills or rocks, their hair might become grass or bushes, their tools or implements may be transformed into stone or rock formations".

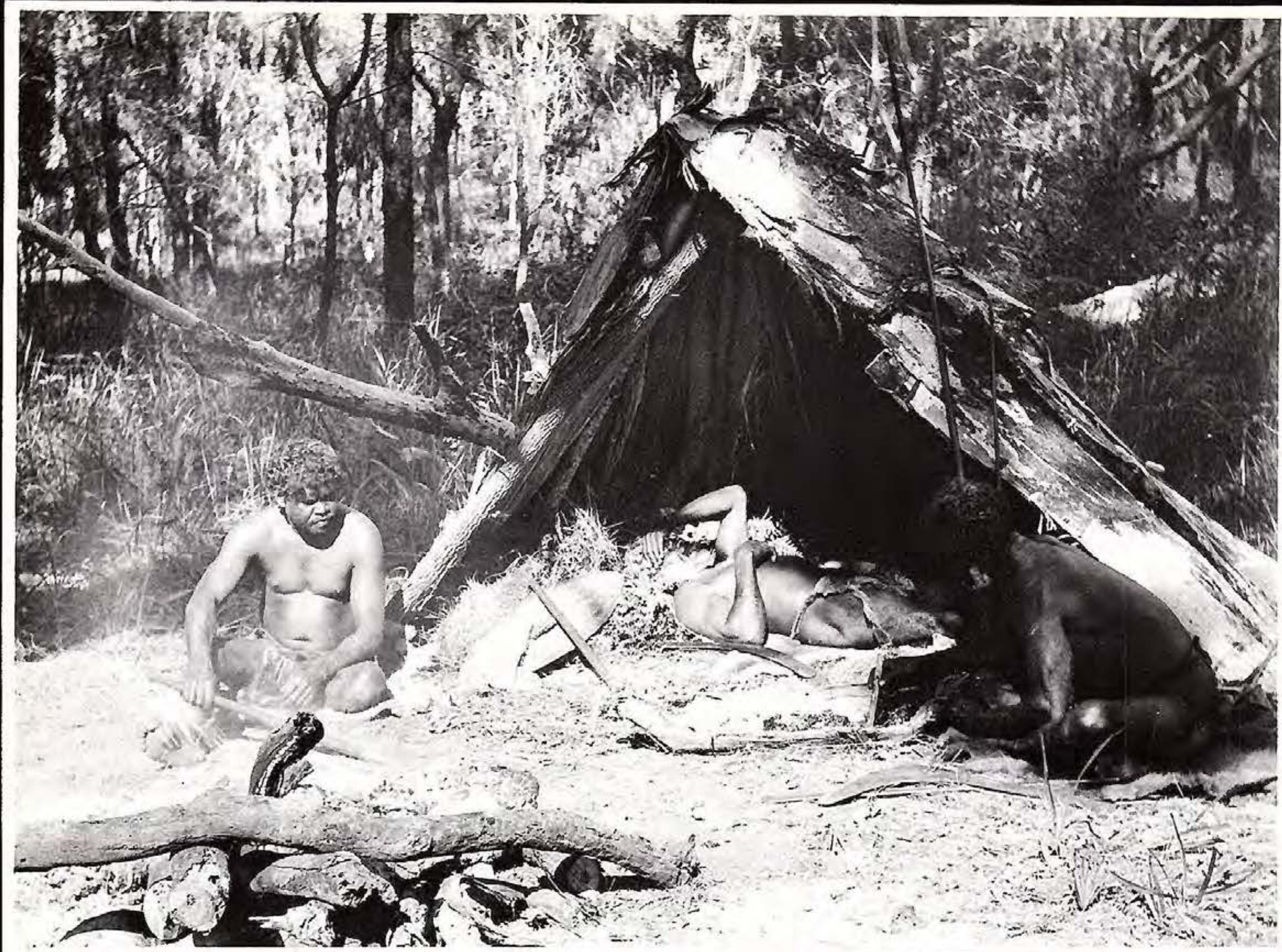
As these different areas became part of the Spirit Beings, they became sacred to the Aboriginals. Caves were often favoured as sacred sites and the tracks, figures and shapes engraved on rock walls, etc, number some of the earliest records of art in the world. As the commentary to the audio visual programme points out, ". . . the walls of caves and rock shelters across the continent are covered with Spirit Beings and the world they created".

As much of the art is based on the Aborigines sacred beginnings, organisers when selecting pieces to fill the exhibition carefully avoided any objects holding important spiritual meanings to the Aboriginal people. The artists of individual pieces commissioned for the exhibition, carefully removed the important spiritual symbolism which would traditionally be included in their works. Just as a large percentage of objects would be guarded from the sight of women, children and visitors in a tribal setting, so the European Australian is excluded from these special pieces which Aborigines rightfully consider should not be exposed to general view.

Destination—Brisbane

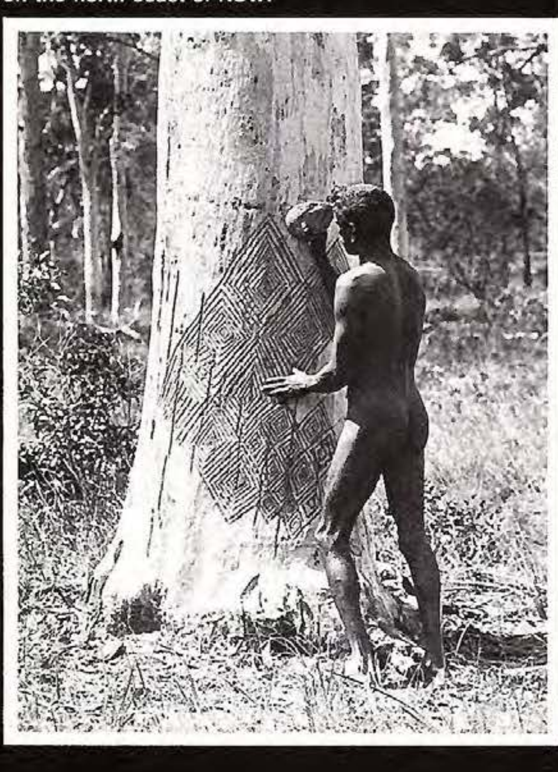
Already the exhibition has been seen by thousands of Australians. It opened in Melbourne in March at the National Gallery of Victoria, then spent some time in Perth. It will remain at the Australian Museum until the end of the Sydney Festival, after which its fate, until the Commonwealth Games in Brisbane, is unknown.

The exhibition marks an important stage in the reassessment of traditional tribal life, art and culture by Australia's Aboriginals, encouraging Australia's 'first' settlers to have a pride in their identity and giving European Australians a greater appreciation of the rich heritage we have in this country.



Three men in camp, using a hut made of bark sheets laid over a wooden frame. A fire is set at the entrance for warmth and cooking, a bark container holds food while clubs, boomerangs, a shield, spears and stone hatchet are ready at hand. The fire of large logs cut by metal axe would not occur in a bush camp before contact with settlers.

Carving designs into a tree using a stone implement. Carved trees such as this were used in initiation ceremonies on the north coast of NSW.



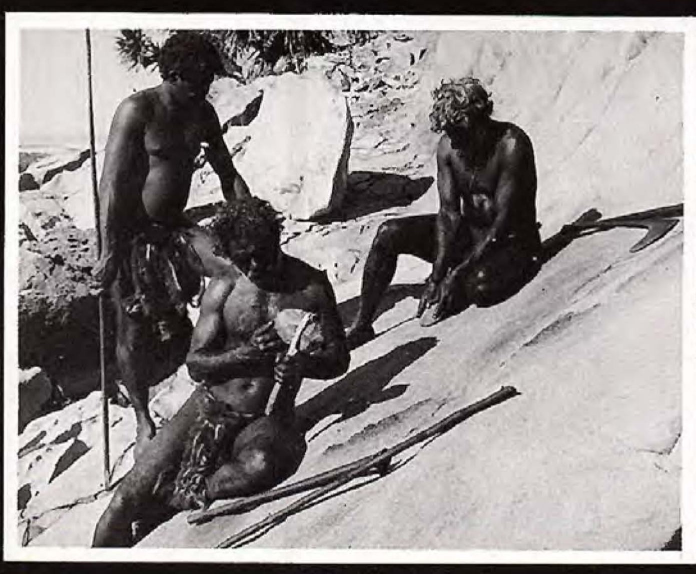
Family group foraging for oysters and other shellfish in tidal mangrove swamps. These areas were rich in resources that could be utilised by the Aborigines.

ABORIGINES IN FOCUS

This group of photographs are part of a series representing the Australian Museum's most important photographic collection of early Aboriginal life. Called the Thomas Dick Collection, after the photographer, the series numbers over a hundred photographs and captures the life of the Aboriginal people of the Port Macquarie locality at the turn of the century. Thomas Dick was a Port Macquarie resident who was extremely interested in the history and way of life of the local Aborigines. At the time increasing European contact was eroding the traditional lifestyle, so in an effort to preserve a record for posterity, Thomas Dick asked a number of local Aborigines to pose for a series of photographs.

The mangroves of estuaries and tidal creeks provided the wood favoured for shield manufacture. In making the shield its form was marked out on the trunk of the tree in a carefully cut groove, this gives the 'blank' for the shield and also allows for the insertion of stone wedges used to remove the 'blank' from the trunk. The butt of a stone hatchet served as a hammer for one man, and flaked pebble for the other. After use the stone wedges were discarded at the base of the tree.

Relaxing by a creek. The bark canoe of coastal Aborigines was simply a single piece of bark bent into the appropriate shape and tied at each end.

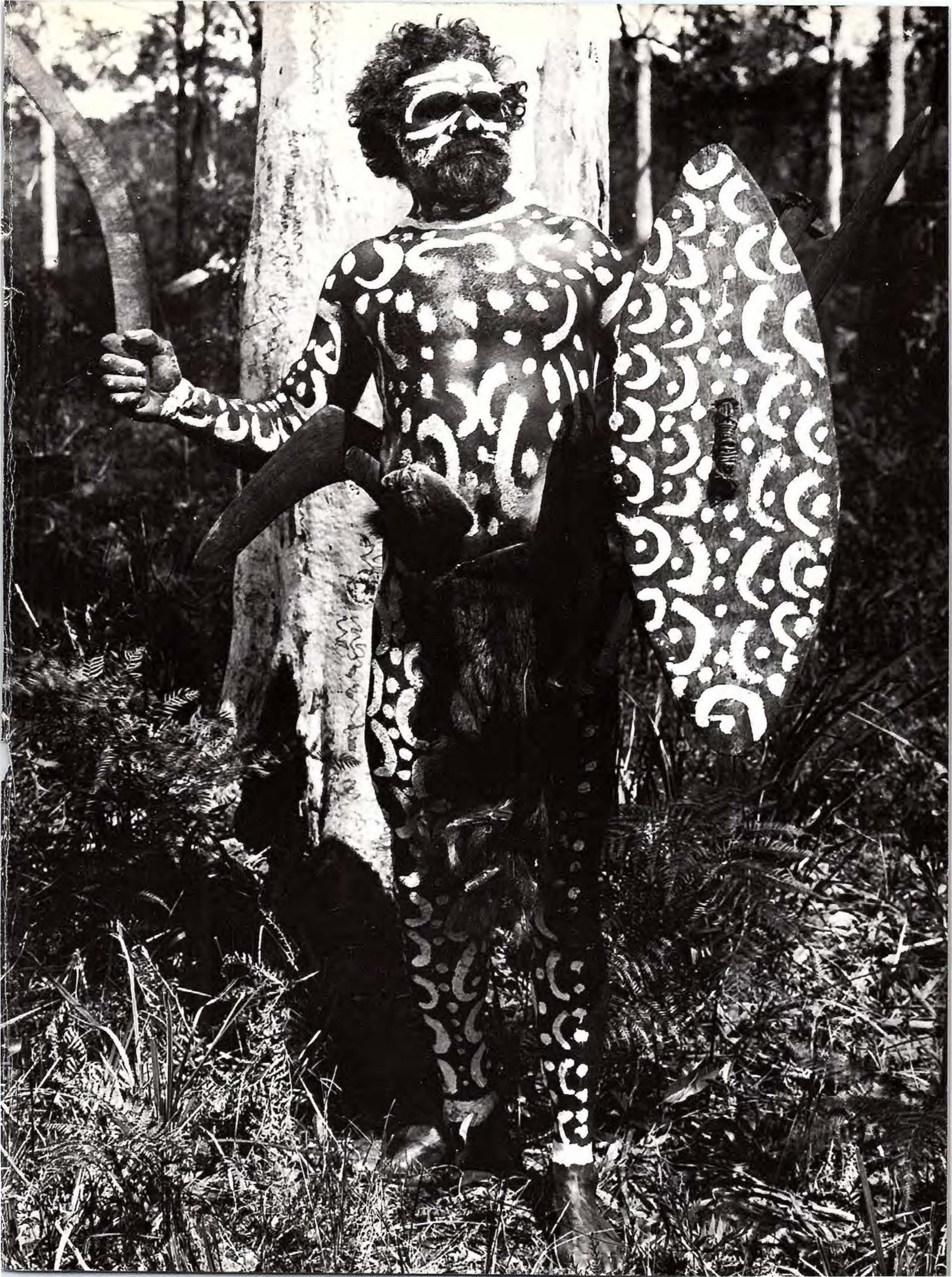


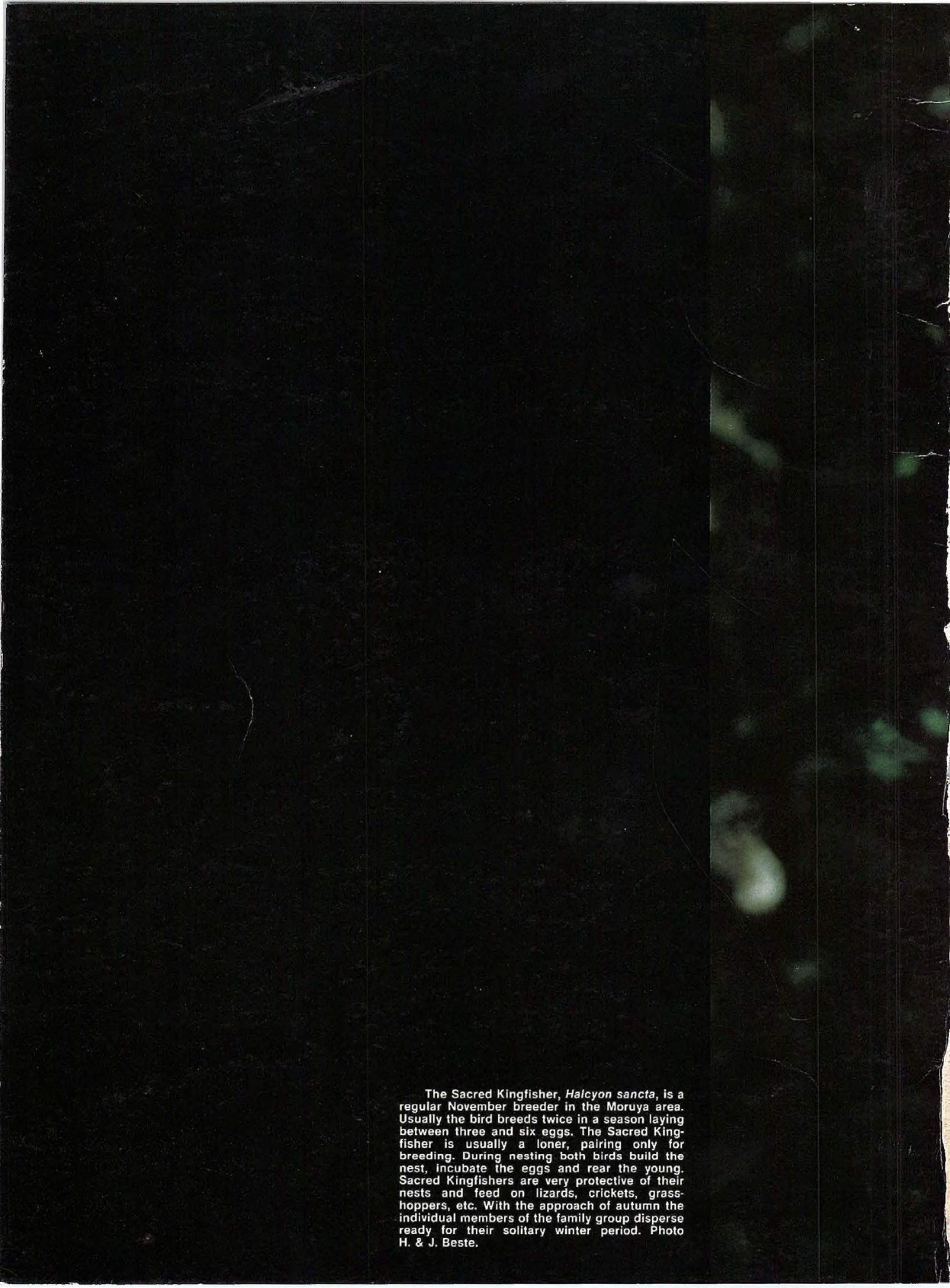
Tool sharpening was one of the daily tasks performed by the men. They grind the stone implements against sandstone which leaves grooves in the rock. The axe in the foreground has been hafted for use.

During hut construction stone hatchets were used to strip sheets of fine paper bark from the coastal swamps. Shorter sheets were cut for this task rather than for canoe making. Multi-pronged fishing spears rest against the trees, while 'leonile' fighting clubs, locally called 'Kopeng' or 'Coupon', boomerangs and spear throwers were piled together on the ground along with a painted shield.

Opposite, ceremonial body decoration was also used on wooden implements such as the mangrove bark shield shown here.

Returning from the hunt with a koala and wallaby on one shoulder and an echidna, snake and lizard carried in each hand.





The Sacred Kingfisher, *Halcyon sancta*, is a regular November breeder in the Moruya area. Usually the bird breeds twice in a season laying between three and six eggs. The Sacred Kingfisher is usually a loner, pairing only for breeding. During nesting both birds build the nest, incubate the eggs and rear the young. Sacred Kingfishers are very protective of their nests and feed on lizards, crickets, grasshoppers, etc. With the approach of autumn the individual members of the family group disperse ready for their solitary winter period. Photo H. & J. Beste.