

# AUSTRALIAN NATURAL HISTORY

A photograph of a yellow and orange lizard-like creature, possibly a gecko, resting on a white, hand-shaped object against a dark green background. The creature has a mottled pattern of yellow, orange, and red on its body. The white object is a flat, hand-shaped piece of paper or cardstock. The background is a dark green, textured surface, possibly a rock or bark.

OCTOBER-DECEMBER 1979 VOLUME 19 NUMBER 12 \$7.50\*



# AUSTRALIAN NATURAL HISTORY

## a new face

This is the last issue of this magazine in Volume 19. Issue number one in Volume 20 will have a completely new look.

There will be a new cover, layout, more colour, more photographs and articles of interest to you. We're sure you'll find it an exciting improvement. You might have already noticed the addition of a centrefold photograph. In all but the special issues it will feature an Australian animal with information about that animal and will be most suitable as project sheets or merely as an excellent photograph to keep.

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# AUSTRALIAN NATURAL HISTORY

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This delightful specimen of an Australian native pine, *Microstrobos*, is restricted to the base of Wentworth Falls, Blue Mountains, NSW. See p. 386 *Australian Native Pines* by P. Regal. Photo: John Fields/Australian Museum

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# AUSTRALIA'S OWN PINES

BY PHILIP REGAL

Hoop pine, *Araucaria cunninghami*, raises its regal head above the sub-tropical rainforest in Wiangaree State Forest, near Kyogle, NSW. Well known for its commercial usefulness *A. cunninghami*, with its fellow native pines, plays an equally important, though lesser known role in the study of forest ecology, plant evolution, and earth's history.

Conifers such as California's redwoods and the kauri pines of Australia and New Zealand, are among the world's best known, largest and most economically and aesthetically valuable trees. Their hardiness and the fact that they dominate great tracts of land in some countries might lead one to assume that they are the most recent examples of the evolutionary process; they are not. On the contrary, conifers are living fossils.

True pines *Pinus* are not native to Australia but have been introduced extensively as ornamentals and for timber. Yet Australia has a variety of endemic conifers: native pines, such as the black kauri *Agathis micho-stachya*, the bunya *Araucaria bidwillii*, hoop, *A. cunninghami*, King William *Arthrotaxis selaginoides*, huon, *Dacrydium franklini*, celery-top, *Phyllocladus aspenifolius*, and various cypress *Callitris* pines. Some 40 species in 11 genera dominate a few small areas of the Australian landscape. Yet, in addition to their economic significance, they are important to scientists studying forest ecology, plant evolution, and Earth's history. Conifers belong to ancient non-flowering plant taxonomic groups with relatively few living species. In all the world there are only about 580 species (in 57 genera) of conifers and their closest relatives, the taxads. By contrast, in Australia there are more species than this in one flowering plant, genus *Acacia*, and nearly as many in *Eucalyptus*. Indeed, the flowering plant group has produced no fewer than 12,334 genera in 349 families: well over 20 angiosperm genera for every conifer species!

The dominant plants today in most of the world, and particularly in tropical and subtropical habitats, are the angiosperms: flowering plants, bearing true flowers. Between 115 and 85 million years ago in the Cretaceous, era, flowering plants underwent an explosive period of evolution in which the numbers and variety of species increased dramatically. While dinosaurs still walked the earth there was an ecological revolution and flowering plants became the dominant and, in many communities, the only types of woody plants. First they conquered the tropics and then spread towards the poles, gradually replacing coniferous trees and many other plants belonging to older taxonomic groups.

However, conifers and other primitive plants continue

to flourish today over many areas of Earth's land surface, mostly outside the tropics. Great forests of coniferous trees such as the true pines, spruce, fir, redwoods and hemlock are found throughout Europe, Siberia, Japan, China, Canada, northern United States of America and the highlands of Mexico and Central America. Since conifers are successful over such broad geographic areas it is difficult to believe they are an inferior group replaced in many areas by a younger, superior group. Evolutionists and ecologists today have learned how important it is to carefully define the particular conditions under which one creature can be considered superior to another. That is to say, conifers may generally be adapted for certain ecological conditions and flowering plants for others, but what are the conditions which cause each group to flourish best?

This has not been an easy question to answer. In Europe and North America, one finds coniferous forests on mountain tops and at higher, cooler latitudes. Northern Hemisphere scientists therefore sometimes assume pines and other evergreen 'Christmas trees' are adapted for the freezing winters in these habitats. This cannot be the whole story. Pines and other conifers are also common elsewhere, under conditions which are ecologically harsh but where freezing is not a problem. Some even occur on the hot wet equatorial lowlands, as in Borneo and the Solomon Islands. Their habitats include areas which are sandy, swampy, of poor soil, fire and drought-prone, adjacent to archetypal desert vegetation. From there it appears the distribution of conifers is paradoxical: an ancient group of plants thrives in harsh habitats where its species have not yet been replaced by the most recent and presumably more successful and vigorous flowering species. One would think that if the flowering plants were generally superior then they would have quickly excluded the primitive residents from these more demanding habitats. Further, conifer habitats, ranging from wet to arid areas, and from tropical to nearly polar climates, at first appear to have no common denominator, making it difficult to assign particular physiological strengths or limitations to conifers.

The author has recently presented reasons to suppose that the advantage flowering plants held in evolutionary

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history was largely related to their pollination by insects, birds and bats. These flying creatures will carry pollen long distances, allowing individuals in a plant population to be widely scattered and still reproduce sexually, and by such outcrossing avoid inbreeding depression. The evolution of true flowers may have allowed angiosperms to flourish first as rare or infrequent species in ecosystems. Eventually enough 'rare' species evolved to form physically and biologically complex ecological communities such as tropical rainforests. In tropical rainforests one can see from 60 to as many as 300 species of trees in a brief walk. On the other hand, temperate forests are often dominated by only one or two tree species and it would be unusual to see even 40 species in a brief walk.

Nearly all plants of species-rich tropical forests are today pollinated by insects, birds, and bats. Indeed, plant morphologists and palaeobotanists believe that the angiospermous flower originated as an organ for insect pollination. It is a complex structure which not only attracts insects but at the same time protects nutritious ovules and seeds in a closed carpel from insect predation. On the other hand, gymnosperms as conifers and their allied plants are termed, have naked seeds and the ovules would be vulnerable to predation if the plant were to advertise them widely through petals and scents. So gymnosperms may have only limited potential to evolve insect pollination systems.

Insects may be particularly important for the breeding of tropical plants today because the forests have very large numbers of species, most of which are rare and widely separated from other individuals of their species. To be reliable, wind pollination requires a dense cloud of pollen grains and unless unusual wind conditions occur may be highly uncertain in open spaces after thirty to fifty metres, even for large trees. This suggests that the evolution of the angiospermous flower allowed more rare species to be added to tropical communities while the coniferous species, which are limited to wind pollination, were diluted by competition. Eventually they were replaced by flowering plants and proved most vulnerable in species-rich communities. This argument predicts that the critical thing the conifers share today is their survival in situations where species-richness has been kept low by environmental harshness. Perhaps in these habitats they can live as relatively common species and so wind-pollination does not become a disadvantage in competition.

The Northern Hemisphere temperate conifers are relatively well-studied and fit this pattern well but what of tropical conifers, Southern Hemisphere conifers in general, and Australian conifers in particular?

Considerable study of Australasian forests is needed. Yet we may predict from the available information that conifers here will also fit the pattern. New Zealand's rain forests seem complex at first glance because there is a dense tangle of vines, mosses, ferns and other undergrowth. However, contrary to popular opinion, there are few species of trees in any one area; two dozen species might be maximum. So New Zealand's many conifer species are not faced with problems of being widely spaced in species-rich forests. Reasons for the low



Figure 10. Coniferous forest of New Zealand.



species-richness of New Zealand trees may include the cool climate, and remoteness combined with widespread volcanism and glaciation in the recent geological past. As these disturbances produced extinctions, the species could not be replaced quickly with immigrants from abroad.

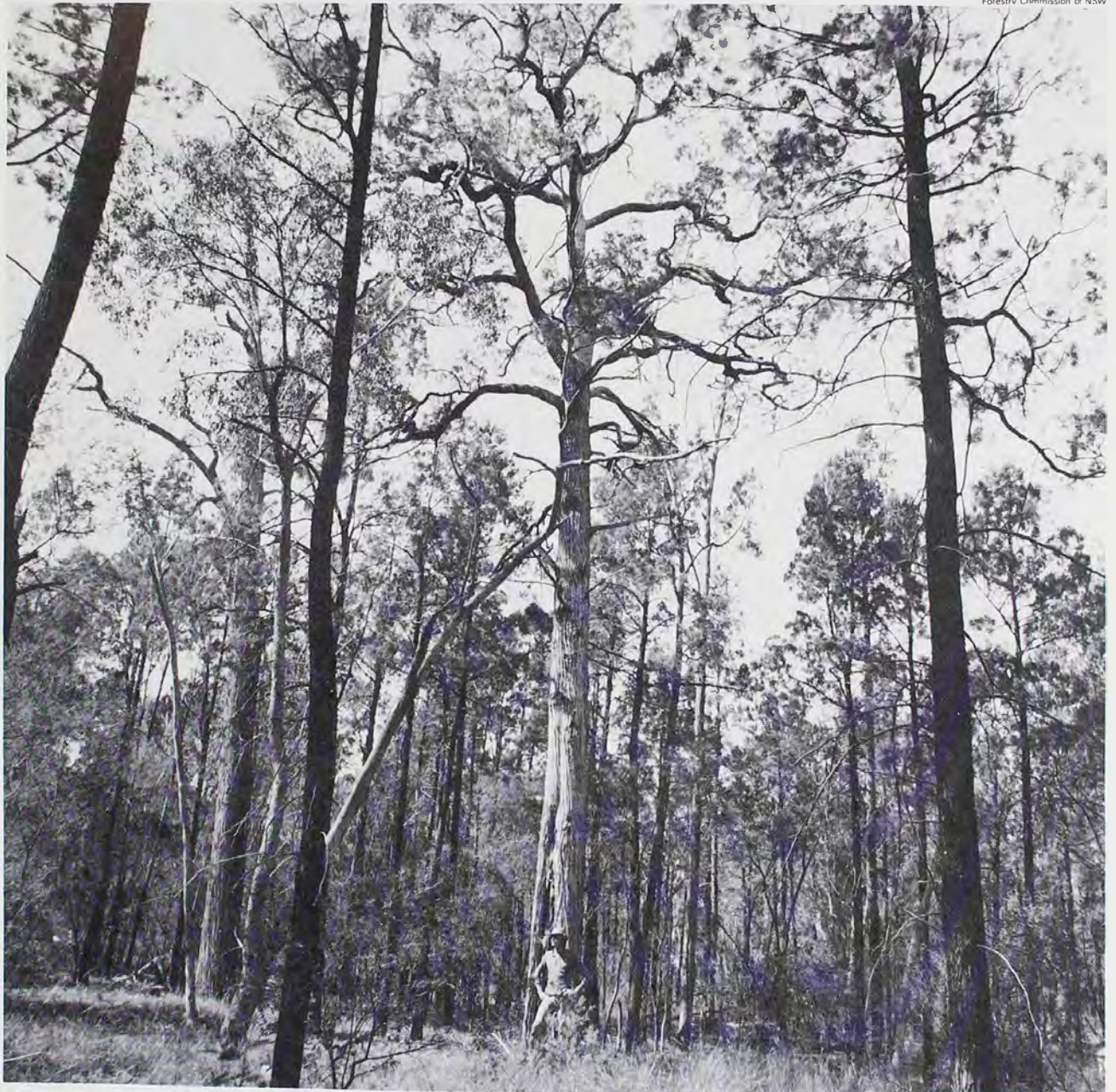
When thinking of conifers, it is convenient to distinguish three basic types of Australian forest. Two types of rainforest are found in small habitat 'islands' of suitable soil and moisture along the east coast. The chain of 'islands' stretches from the cool temperate rainforests of Tasmania to the tropical rainforests of Queensland. Fires seldom penetrate these areas which are refuges for some of Australia's most interesting and least known wildlife. The 'islands' are surrounded by an ecological sea of fire. Adjacent to them and covering much of the continent are the familiar eucalyptus dominated sclerophyll forests maintained by frequent cycles of fire. Sclerophyll species show many adaptations for fire and drought, and the flora of much of the continent is characterized by a few familiar genera: *Eucalyptus*,

*Banksia*, *Acacia*, *Hakea*, *Grevillea*, *Casuarina*, *Melaleuca*.

Most of Australia's conifer genera are in the temperate and tropical rainforests. In Tasmania, the species-richness is low and wind pollination should present no handicap. But the tropical and subtropical rainforests of the north have high, dense canopies of scores of species. Wide spacing is common and might seem to present severe problems for wind pollinated species. The work of L. Webb and J. Tracey of the CSIRO indicates that *Araucaria* and *Agathis* are gregarious and found in pockets at the physiological edges of the rainforests. Where the moisture stress is high or soil fertility low, but not severe enough to favor sclerophyll species, the broadleaf angiosperms are relatively stunted. It is above the low subcanopy which angiosperms form in such marginal areas that the stands of *Agathis* and *Araucaria* tower. In such situations, wind pollination should not be a handicap. In rainforests of only slightly reduced tropical lushness are species of *Podocarpus*. These are sometimes said to be scattered throughout the forest and they may be an exception to the generalisations that seem to

Forestry Commission of NSW

Fire-scarred veteran white cypress pine, *Callitris columellaris*, 'inland' form—is one of the forty species of pines to be found in Australia. This specimen towers over the natural regrowth at Meriwindi State Forest, near Baradine, NSW.





apply to other conifers. But *Podocarpus* are unusual among conifers in having fleshy fruits instead of hard cones and their seeds are dispersed by birds. So the scattered trees may represent many isolated individuals and not breeding populations. More study is needed to understand the ecology of *Podocarpus*.

The nineteen species of Cypress pines, *Callitris* and *Actinostrobus*, are not found in rainforests. They are virtually the only genera of conifers to survive in Australia's vast sclerophyll forests. Much work is needed to understand their ecology, but data indicate that they are generally gregarious, like sclerophyll trees they are in species-poor stands, and wind pollination should not handicap them.

The available information suggests some basic similarities between Australian and North American conifer ecology. There are also some major interesting differences. For example, biologists visiting from overseas may be impressed by the many pine-like angiosperms in the sclerophyll forests. Species of *Casuarina*, *Hakea*, *Banksia*, *Grevillea* and *Acacia* are only some of the more

common examples of trees and shrubs with tough needle-like 'leaves'. The seeds of many may be protected in hard woody fruits that recall pine cones at least with respect to function. Moreover, many such species live in habitats occupied by conifers in the Northern Hemisphere. These include drier areas, areas with poor soils, and those with frequent fire cycles. Like conifers of the North American closed-cone pine forests, some of the Australian counterparts save their major seed release for post-fire conditions. Why should such 'roles' have been filled extensively by conifers in North America, but mostly by angiosperms in Australia?

The answer to this question is very likely linked to Australia's unusual ecological conditions and at least in part to its interesting history throughout the last forty-five million years. Today Australia is the world's most arid continent. Its relief is low and there are no extensive high mountain systems that cause air masses to rise and cool, resulting in condensation of moisture and consequently rainfall. In addition, the continent is in a climatic zone roughly midway between the northern tropical weather

This pure stand of natural regrowth cypress pine probably dates from 1890-1900 when grazing in this area was abandoned.







system that brings much of the summer rainfall, and the southern winter rainfall weather system. Being marginal to both great weather systems, the amount and timing of rainfall is notoriously difficult to predict over much of the continent. These factors, together with some of the world's least fertile soils have profound effects on Australian ecology.

Drought is a well known agricultural problem and also has a variety of effects on the plants and wildlife, if only in contributing to the widespread success of fire-adapted plant species. Over large areas of the continent there may be abundant rainfall in years when the great weather systems penetrate the arid latitudes to an unusual degree. These may be times of particularly vigorous plant growth. Much fuel accumulates. Inevitably, drought follows and the accumulated vegetation can become tinder dry. Lightning starts fires that in former times ranged widely and often with tremendous intensity, depending on the amount of fuel accumulated during the wet years, and on the degree of drought. Deliberate burning by Aborigines is believed to have increased the geographic extent of the fire-maintained sclerophyll forests; but surely they were extensive on the continent before man.

In roughly similar climatic areas at the same latitudes in the Northern Hemisphere drought and fire may also be common although the extensive mountain systems may have a variety of modifying effects. For example, they may make rainfall somewhat more predictable on their windward sides, while casting rainshadows in which little fuel can accumulate. So fire would be quite rare throughout most of North America's desert. In these latitudes in the Northern Hemisphere many angiosperms show structural and physiological adaptations to drought and even fire. In addition, many species of the true pines *Pinus* and other conifers often dominate the forests, are drought resistant, and some have fire resistant bark and seeds protected in woody cones.

In Australia the sclerophyll forests are made up almost entirely of angiosperm species, while most of the conifer genera are found in wet habitats such as the rainforests or Tasmania's mountains.

It is an important fact that Australia did not always occupy its present position on Earth's surface. At the time of the extinction of the dinosaurs, Australia was attached to Antarctica and geologists tell us that it was some 15° of latitude further south than today. It broke loose from Antarctica about forty-five million years ago at which time the city of Brisbane would have been roughly where Hobart is now. This and actual fossil evidence suggest that the continent was much wetter then and probably warmer as well, with mixed forests including *Nothofagus* (southern beeches) *Photeaceae*, *Casuarina* and conifers.

J.S. Beard of the University of Western Australia has proposed that the evolution of the more drought-adapted plants resulted from Australia's drift out of the dominant influence of the southern weather system into the more arid latitudes. So at the time that Australia was developing drought and fire adapted plants, a variety of angiosperms were present on Earth as a result of more than fifty million years of evolution. The author suggests that we imagine a new habitat being invaded from a rich flora



with diverse systems of pollination, physiology, and the like. Perhaps it was inevitable that following the great adaptive radiation of the angiosperms, most of the pioneers into the new arid zones belonged to flowering plant groups. On the other hand, the land masses of the Northern Hemisphere have been situated in the arid latitudes for considerably longer than Australia. Indeed, before angiosperms appear in the fossil record, Northern Hemisphere land masses were located such that drought and possibly fire fell upon some of the conifers that grew on them. We can imagine adaptation of conifers to that climate having taken place without any competition from angiosperms. Of course, eventually, angiosperms were added to the vegetation of these areas, but they have not yet entirely displaced the prior occupants.

The present distribution of Australian conifers fits this scenario rather well, with most of the genera in wet refuges along the east coast. While *Callitris* is widespread throughout sclerophyll forest areas, it may well in a sense escape the full severity of conditions that favour the angiosperms and so on a small scale it might be thought of as a relict.

It is sometimes said that Cypress pines are found in fire-protected microhabitats such as very rocky areas. Here the frequency of fire is presumed to be not so great as in nearby areas. Cypress pines are also said to actually repel fire. The mechanisms are not well understood, but several ecologists have pointed out to me that due to shading or some chemical effects of the pines themselves there is little undergrowth in pine stands. So a ground fire may burn up to the edge of a grove and stop. A more intense crown fire, of course, will destroy the pines. *Callitris* and its Western Australian relative *Actinostrobus* occur throughout a vast area including most of the continent, so any such impressions are much in need of supporting studies.

The conifers of the wet refuges show interesting patterns of distribution that reflect historical events in Australasia.

Tasmania is unrivaled as a refuge for Australian conifers. *Athrotaxis*, *Microcachrys*, *Dacrydium*, *Phyllocladus* and *Diselma* are found nowhere else in Australia. *Microstrobos* is known elsewhere only by a single species restricted to the base of Wentworth Falls in the Blue Mountains of New South Wales. These six genera of cool Tasmania constitute more than half of Australia's eleven conifer genera. That they are refugees from ecological changes on the continent is suggested by examining their distribution in both space and time.

*Athrotaxis* is known from Cretaceous fossils in Chile, Cretaceous and Tertiary fossils from New Zealand, and Tertiary fossils from New South Wales and Queensland. So species of *Athrotaxis* must have been widespread throughout the southern continents when they were more closely connected as Gondwanaland 100 million years ago.

*Dacrydium* and *Phyllocladus* are absent from the Australian continent, but have distributions that fringe it with species throughout New Zealand, New Caledonia, Fiji, Papua New Guinea, parts of Indonesia and the Philippines. *Dacrydium* also ranges beyond this to parts of the Indo-Malayan peninsula and Chile. In both cases, Tertiary

fossils confirm that these genera once lived in Australia. Pollen profiles from crater lakes in the Atherton Tableland of northern Queensland show that even relatively recently, in the Pleistocene period, *Dacrydium* flourished in a conifer-dominated forest that also included *Agathis* and *Araucaria*.

*Agathis* and *Araucaria* have patchy, fragmented distributions within the tropical and subtropical rainforests of Queensland and northern-most New South Wales. Present and past distributions indicate that once they also had widespread distributions throughout Gondwanaland. Today *Araucaria* is found in New Caledonia, Papua New Guinea, Norfolk Island, New Hebrides, South America, with fossil records from New Zealand, South Africa and Antarctica where it is now absent. *Agathis* includes the great kauri pine of New Zealand (*A. australis*) and is also represented by species ranging over an area from New Caledonia and Fiji to the Philippine Islands and the Malay Peninsula.

*Podocarpus* is widely distributed, primarily throughout the world's tropics, and with about 100 species it is the largest conifer genus. Most Australian species are in wetter areas along the east coast and range in life-form from a low alpine bush in Tasmania to tropical rain forest trees in Queensland. There is also a species in the seasonally dry Jarrah forests of Western Australia. This native plum or emu berry (*P. drouyniana*) is reported to be able to regrow after fires from underground storage organs. Such an adaptation is common in sclerophyll plants such as *Eucalyptus*. But the only other Australian conifer known to have such a capacity is the Western Australian *Actinostrobus acuminatus*.

Viewed through geological time, Australia itself is an immigrant. Some forty-five million years ago it began a journey from a region which, if at times cool, was at least reliably well-watered. Slowly it proceeded on its journey into one of the most demanding areas on Earth. Some of the flowering plant passengers adapted to the most severe conditions. Others, along with most of the conifers, fell back to situations where they could maintain familiar habits. In these areas they are vigorous and can hold their own against all but the over-zealous saw and axe. These ancient plants survived the appetites of dinosaurs and then survived whatever conditions killed the dinosaurs. They survived 100 million years of competition from the flowering plants. They have survived the wandering of their continent into a new and demanding climatic region.

There is indeed a great beauty in the form and colour of these trees and shrubs and the forests that they form. But there is also a beauty in the rich story of their survival and in the history and diversity that they contribute to Australia.

#### FURTHER READING

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- Florin, R. *The Distribution of Conifer and Taxad Genera in Time and Space*, *Acta Hori Bergiani* 20: 121-312, 1963.
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Black cypress, *Callitris endlicheria*, with eucalypt and wattles in Timmiallie State Forest near Baradine. In addition to the vast pine plantation schemes the NSW Forestry Commission conducts a consistent policy of enrichment planting to build up stocks in natural pine forest areas.



# BIRD HISTORY —the first one hundred million years

BY PAT V. RICH AND RITA BERRA

## Introduction

Over a century ago scientists knew that the history of birds stretched back some 150 million years into the 'Age of Reptiles' (Mesozoic era). By 1861 two significant finds by workmen quarrying Jurassic lithographic limestone in southern Germany firmly established the great antiquity of birds. One specimen was a single feather; the other was a skeleton, which by 1862 had been purchased by the British Museum of Natural History, London, providing a handsome dowry for the daughter of Dr Frederick Karl Haberlein.<sup>1</sup> Renowned British anatomist Sir Richard Owen studied the skeleton, and his thorough description established the uniqueness of *Archaeopteryx*, a form new to science in the mid-19th century, that even today sparks palaeontological controversy.

A 25 million year gap separates *Archaeopteryx* and the first varied record of birds. A femur from a bird perhaps distantly related to flamingoes and a few feathers are all that bridge this gap. Only in the late Cretaceous period,

a time of major extinction for many animals, are a few kinds of birds known, all distantly related to modern types.

During the first 40 million years of the Cenozoic era, from about 65-25 million years ago, birds gradually assumed a modern visage. Early Cenozoic birds were still only distantly related to living bird families and were often characterized by a mosaic or composite of the features that define modern groups: these form intermediate links between quite distinct groups of living birds. By Eocene times (55 million years ago) modern families began to appear (eg: ducks); by 20 million years ago (Miocene period) the bird fauna was essentially modern in aspect.

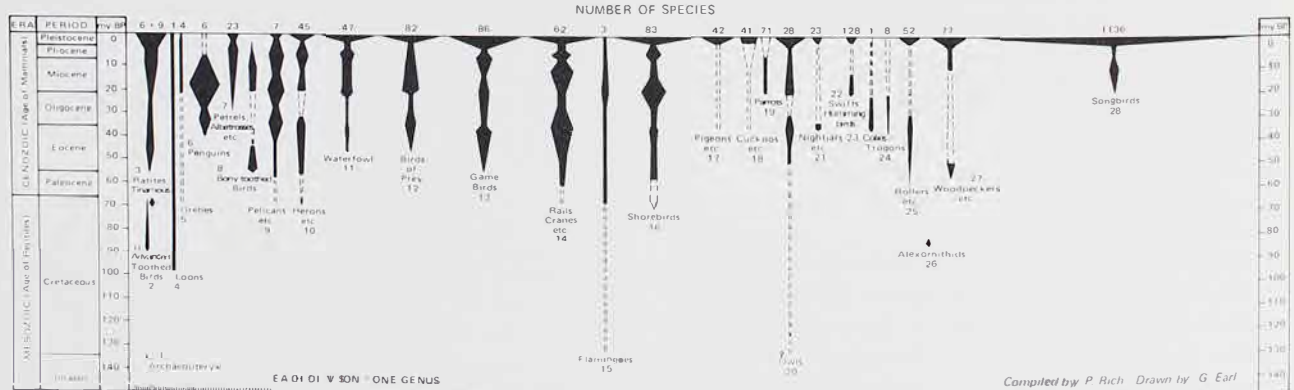
The following article dwells only on the first one hundred million years of avian history, an inconceivable amount of time in human terms, but only the early history of birds.

## The Origin of Birds: New Ideas on an Old Subject

If one follows the evidence of fossil birds back through time to its beginning, one inevitably ends at *Ar-*

<sup>1</sup>Haberlein, a medical officer in the district where the oldest birds have been found, was often paid with fossil specimens. He somehow acquired the first skeleton of *Archaeopteryx* which he sold to the British Museum.

PAT V. RICH is a lecturer in the Earth Sciences Department at Monash University whose main research interests centre around fossil birds from the southern hemisphere, particularly their origins, interrelationships, and distribution patterns. RITA BERRA is a research assistant in the Earth Sciences Department at Monash University whose main duties involve preparation, moulding and casting of fossil vertebrates from Australian Tertiary deposits. She is involved in numerous research projects involving past diversity of birds and determination of what happens to bird bones in different sedimentary environments.





*chaopteryx* (meaning 'ancient wing') recovered from the late Jurassic lithographic limestones of southern Germany. This form is well known to laymen and fossil workers alike. Now known from five partial skeletons and an isolated feather impression, *Archaeopteryx* is regarded as a bird by most ornithologists because some of the skeletons clearly show associated feather impressions. It is by no means 100% bird, but displays a mosaic of reptilian and avian features, some more reptilian than avian, eg: toothed jaws and an elongate tail.

One might assume that because *Archaeopteryx* specimens have been known for so long its relationships to other vertebrates as well as knowledge of its life style would be relatively well understood. On the contrary, these fossils remain the focus of continued scientific debate. 'Is *Archaeopteryx* more closely related to crocodiles or to dinosaurs in the reptile line?' or, 'did it, or did it not, fly?' are questions currently being debated in scientific journals, and no crystal-clear picture has emerged.

John Ostrom (Yale University) is the most recent extensive reviewer of the original *Archaeopteryx* material, as well as of new specimens recognised in museum collections during the past decade. After meticulous examination of all the available material, Ostrom (1975) concluded that *Archaeopteryx* was strikingly similar to some small, bipedal dinosaurs, the coelurosaurs, which probably fed on insects or small vertebrates, thus reviving an old theory, popular during the late 19th century. Ostrom noted, particularly, certain detailed resemblances between the hand, forelimbs, and shoulder girdle of *Archaeopteryx* and coelurosaurian dinosaurs. Some scientists still disagree, suggesting crocodylian or very primitive reptilian affinities (Walker, 1972; Whetstone and Martin, 1979), but many of Ostrom's ideas hold the current tide of popularity within scientific circles and have assuredly caught the imagination of the general public.

Yet another controversy rages over *Archaeopteryx*'s ability (or inability) to fly. Was it a runner, a glider, a flapper, or what? Feathers, as a unique structure may originally have had nothing to do with flight but probably developed as insulation to help in retaining body heat more efficiently. Why body (or contour) feathers developed into typical flight feathers is another problem, which has been explained in several ways. Ostrom (1974) cautiously suggested the novel idea that contour feathers may have been modified on the forelimb to "enhance the prey-catching function of the hands" in much the same way as a butterfly net aids the entomologist.

Although such 'feathered dinosaurs' (or early birds) were very good runners, Ostrom concluded that they probably did not fly because they lack virtually all of the specialised structures essential for flight in modern birds (Ostrom 1979), such as, lack of a sternum (breast bone), fragile coracoids, absence of a triosseal canal, and lack of tubercles for attachment of muscles that fold the wing on the humerus. Recent work by Feduccia and Tordoff, (1979), on the forelimb feathers of *Archaeopteryx* indicates that some of these feathers are not symmetric — that is, one vane has a larger surface area than the other (a feather consists of a central support [shaft] separating a sheet of inter-locking barbs on either side, called



with permission of Shell New Zealand

vanes). In modern flying birds the smaller vane always occurs on the leading edge of the feather, the part in closest contact with the air flow when a bird is flying or gliding. Such asymmetry in modern birds is consistently present in both fliers and gliders and generally lacking in flightless forms. Feduccia and Tordoff, therefore, reason that *Archaeopteryx* could at least glide and was not tied entirely to a bipedal life style. Body feathers of both fliers and non-fliers can show such asymmetry (Ostrom, pers. comm.), and thus the controversy wages on!

Restoration of one of the bony or false-toothed birds. *Pseudodontornis* from New Zealand, which had an estimated 4.5m wingspread. Relatives of this form first appeared during the Eocene and survived until the Pliocene.

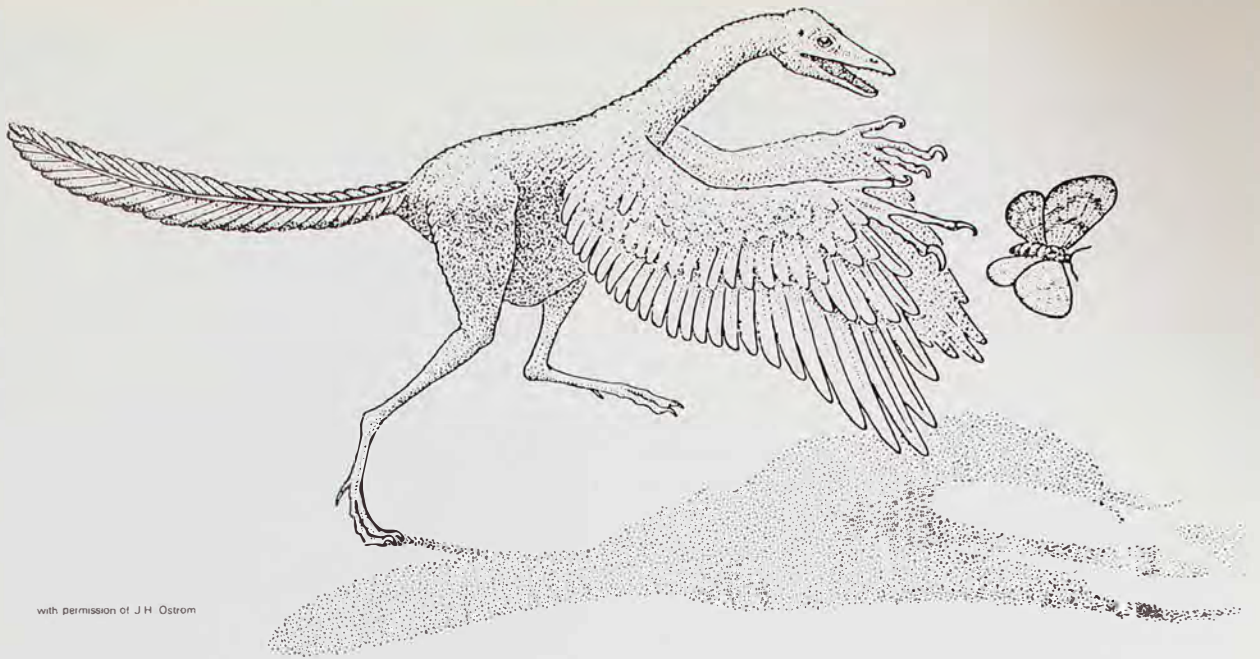
### The Cretaceous Period: First Records of Birds

About 90 million years ago the first undisputed birds appear in the fossil record. In the time between *Archaeopteryx* and these first birds, bones of supposed loons, flamingoes, and owls are reported, but the authenticity of some of these records has been questioned; a few other fossils reported from this time and originally assigned to new, extinct groups of birds have recently turned out to be dinosaurs after re-examination (Brod-korb, 1978). By the end of the cretaceous, about 65 million years ago, at least 12 families of birds had appeared, all but one of which were waterbirds.

Perhaps the most intriguing of these 'early birds' are the toothed forms, members of the order *Hesperornithiformes*. From the moment these birds were discovered (including *Hesperornis*, *Baptornis*, and *Ichthyornis*), they were used as evolutionary 'missing links' between the 'toothed' reptiles and the 'toothless' modern birds. Because such palaeontological links were so scarce, as noted by Charles Darwin himself in **The Origin of Species**, the importance of such birds should not be underestimated; in the early 1870s they lent persuasive and needed support for Darwin's ideas about organic evolution by natural selection.

*Hesperornis* and *Baptornis*, both closely related, were relatively large birds (some reaching two metres in total length) that were totally dependent on their feet for pro-





with permission of J H Ostrom

Restoration of *Archaeopteryx* utilizing the expanded feathers on the forelimb as a butterfly net, an idea suggested by Yale's Dr John Ostrom to explain why many feathers on the wing were decidedly larger than those on the body: a larger surface area of the wing would mean a more efficient net.

pulsion. The wings were highly reduced. They probably fed almost entirely on fish and had elongate toothed jaws, well adapted for slashing through schools of fish or for grasping prey. These birds, together with another toothed, but flying form, *Ichthyornis*, were inhabitants of the great, shallow inland sea that flooded onto the North American continent during the later part of the Cretaceous. Although chalk rich sediments of similar age occur elsewhere in the world (the Chalk Cliffs of Dover, England, for instance) these toothed relics have not yet been found outside North America. By the end of the Cretaceous, these relatively primitive birds had become extinct.

All of the toothed birds, in particular *Hesperornis*, resembled some dinosaurs, such as *Compsognathus*, in certain features. One interesting similarity lies in the structure of their palate; not only are the bird *Hesperornis* and the dinosaur *Compsognathus* very similar, but both in turn are similar to the living ratite birds, such as the ostrich, emu, and rhea. Such similarity suggests that the typical ratite palate (called the *palaeognathus* palate) may be a primitive feature that birds share with certain dinosaurs or, it might have developed more than once in the history of vertebrates in response to similar selection pressures in the environment — a problem yet unresolved. The conformation of the skeletons of both *Archaeopteryx* and the late Mesozoic toothed birds certainly suggests a dinosaurian origin for birds, an idea proposed during Darwin's lifetime that has only regained popularity during the last few years.

Besides the toothed birds, a few other rare specimens of late Mesozoic birds have been found. Perhaps the oldest of these is the occurrence of feathers in early Cretaceous rocks of southern Victoria, Australia, dated at about 120 million years. At least two different kinds are known, but not enough detail is preserved to indicate from what sort of a bird they came. Other early Cretaceous occurrences include the forms *Torotigidae* (from France) and the *Enaliornithidae* (from England) distantly related to flamingoes and to the loons respec-

tively.<sup>2</sup> Although the *torotigids* survived most of the late Mesozoic, they became extinct by 65 million years ago leaving no close relatives.

In reviewing Cretaceous birds, it is quite evident that most are waterbirds — diverse waders, paddlers, and the like. True land birds are rare. The only uncontested terrestrial bird of this age is the recently described *Alexornis*, from Baja California, placed in its own major order of birds, the *Alexornithiformes*. It is truly a mosaic form, structurally intermediate between a group including the woodpeckers, barbets, and kin *Piciformes* and another containing the living rollers and kingfishers *Coraciiformes*.

### Early Cenozoic: A Time of 'Almost Recognisable' Forms

The first period of the Cenozoic era, the Paleocene, 65-55 million years ago boasts little in the way of fossil birds, and much of what is known remains unstudied or is in need of general revision. This is partly due to the shortness of the Paleocene: 10 million years compared to the much longer Cretaceous period, which preceded it, and the small number of Paleocene localities compared to those of other Cenozoic epochs. The Pleistocene period, although even shorter (only three million years long), has a greater number of localities mainly because it is so young, and thus its deposits have experienced far less destruction than older ones. When observing the preserved record of any time period, scientists often find it impossible to sort out just what factors were most important in determining which birds will be preserved as fossils and in what proportions. Do abundances or low numbers of species in the fossil record reflect somewhat accurately the relative proportions when the birds were alive? Or have depositional conditions and post-depositional events radically altered those proportions? Often it is hard to know.

<sup>2</sup>The author adds 'the early Cretaceous forms are perhaps related to *Hesperornithiformes*'.



Sites of early Cenozoic deposits (as with Cretaceous locales) are concentrated in North America and Europe, areas of intensive paleontological activity for over two centuries. The Itaborai site in Brazil is the only one in South America, while several are known in Asia due to a great deal of activity by Polish and Russian vertebrate palaeontologists in southern Russia and Mongolia in recent years (Kurotchkin, in Olson, 1976).

Those birds known from the Paleocene mainly represent families extinct today. They include forms distantly related to grebes, flamingoes, herons, pelicans, and waders. To this list can be added the first member of a modern family, the ducks *Anatidae*, as well as some real surprises: a very primitive owl and two groups of large, highly predacious ground birds. The owl is quite intermediate between the living barn owls *Tytonidae* and typical owls *Strigidae*, rating its own separate family, which was apparently restricted to the late Paleocene of western North America. This primitive owl specimen demonstrates a problem typical of palaeornithology, in that it consists of only a single bone. It is the only evidence of early owl evolution available to date. We have no idea of the appearance of anything other than one leg bone, the tarsometatarsus; if we did, our picture might be drastically altered. If another owl specimen representing a different part of the skeleton were to be found, it would be difficult, if not impossible, to determine if the two specimens belong to the same species. This underlines that any hypothesis about a bird's appearance or relationships is only as good as the material on which it is based, and scientists must be willing to alter hypotheses if more complete material requires it.

A second surprise offered by early Cenozoic fossils is the marked variety of crane-like or rail-like birds that so characterises Paleocene, Eocene and Oligocene avifaunas. One spectacular example is *Diatryma* and its relatives *Diatrymidae* and *Gastornithidae*, which lived

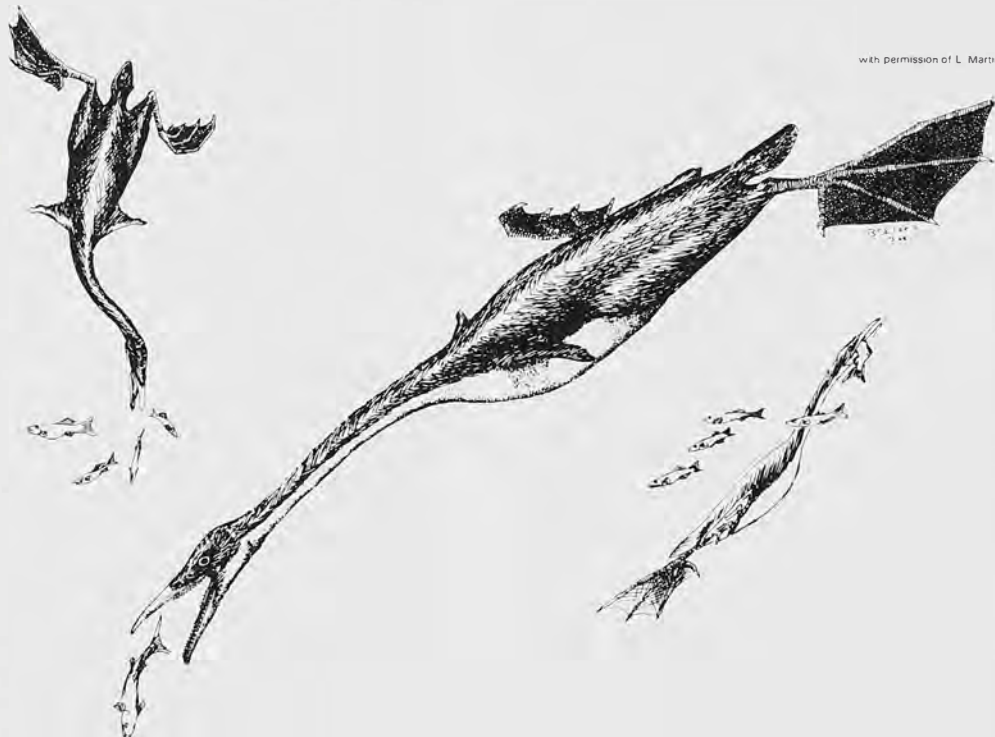
during the Paleocene and Eocene in Europe and North America. *Diatryma* was a large ground bird reaching six feet in height, and unlike the big ground birds of today, such as the emu and the ostrich, it was carnivorous. Although of relatively light build, it had a deep, compressed bill with a distinct hook on the end, quite capable of ripping flesh efficiently or delivering a crippling death bite. Certainly *Diatryma* was the prime carnivore of its time and probably relied on mammals for a large part of its diet, a fitting prepayment for the cat that raids the bird's nest!

### Eocene and Oligocene: Beginnings of Modern Avifauna

The fossil record of birds dramatically blossoms during the 18 million years of the Eocene. Some large, diverse collections of birds are known from Europe and Asia, and to a lesser extent from western North America. The early Eocene London Clay of southern England and the Eocene-Oligocene Phosphorites du Quercy of France have produced large numbers of bones that have served as a major reference point in palaeornithology since the time of Alphonse Milne-Edwards in the 19th century. Large collections of bird bones are also known from Mongolia and Kazakhstan, as a result of recent work by vertebrate palaeontologists in these areas. In contrast, the only South American records are of primitive flamingoes *Telmabatidae*, while those from Australasia are seabirds, mainly penguins. The African record, too, is very limited and consists mainly of marine forms: a bony-toothed bird *Dasyornithidae* and a pelican or heron. At least one African form, however, appears to be related to the elephant birds *Aepyornithidae* that later radiated in Madagascar, leaving a rich Pleistocene avifauna on that island.

In addition to a number of now extinct families which lived during the Eocene, several modern families made

Restoration of the Cretaceous toothed bird *Baptornis*, from chalk deposits in central USA. The webbing on the feet may not be correct on this 70cm long bird.





their first appearance: rheas, loons, cormorants, snake-birds, frigate birds, herons, ibises, storks, new-world vultures, hawks and eagles, secretary-birds, turacos, curassows, rails, bustards, painted snipe, typical owls, sand-grouse, trogons, hornbills and rollers at a minimum. Many of these forms occurred in geographic areas atypical of their present distribution, notably forms such as the secretary-birds, trogons, horn-bills and sand-grouse, all characteristic of Africa and/or Asia today. Fossils of these forms occur in the Eocene London Clay assemblage. It must be borne in mind, that southern England was a very different place then from today, for the plants preserved in the clays suggest a tropical climate typified by humid, swampy conditions more approaching those of lowland Malaysia at the present. The London Clay assemblages are unique in containing a mixture of both upland and lowland plants that apparently coexisted quite happily in the humid lowlands of the Eocene — nowhere today is there an exact counterpart.

Despite the modern appearance of many birds, there was still an archaic element in Eocene avifaunas. The large bony-toothed or false-toothed birds characterised by having tooth-like, bony projections along the bill margins that probably served the same function as real teeth, first appeared in the Eocene and survived as late as the Pliocene period. They were probably among the major carnivores in their marine environment, perhaps with the same general lifestyle as pelicans or albatrosses today; neither pelicans nor albatrosses and kin became established until the latter part of the history of the bony-toothed birds; perhaps these groups had some role in bringing about the extinction of the bony-toothed forms — one can only speculate.

Several families of flamingoes and flamingo-like birds originated in the Eocene: *Telmabatidae*, *Agnopteridae*, *Phoenicopteridae*, but only the phoenicopterids survived beyond the Oligocene, obviously quite successful due to a very specialised life style of feeding on microorganisms in highly saline conditions using a novel 'vacuum pump' arrangement for sieving food out of the water.

Within the *Pelicaniformes*: shorebirds, *Galliformes*: gamebirds and *Gruiformes*: rails, cranes etc, a broad radiation of primitive forms took place during the Eocene as well. Amongst the gamebirds, forms related to the living chachalacas and curassows of the South and Central America were particularly varied. The gruiform assemblage underwent a great deal of change during this time: the gastornithids had become extinct by the end of the Paleocene, and although the diatrymids survived into the Eocene they soon disappeared, perhaps due to fierce competition with some of the larger mammalian carnivores then developing. A number of sub-families of medium-sized ground birds related to modern cranes appeared in the Eocene: *Geranoidinae*, *Eogruinae* only to become extinct soon afterwards or to last just until the mid-Cenozoic. The bustards which appeared at this time, are still with us. In the Oligocene of Asia a family of Gruiformes existed that possessed only two toes, reminiscent of the same specialisation in ostriches that assures more efficient, high speed running. South America, too, boasted a vast radiation of Gruiform types during the early and later Cenozoic, well exemplified by

the phororhacoids. These large ground birds (some with a skull approaching 1m in length) were highly predacious just like *Diatryma* of the Eocene. They occupied the top carnivore role amongst the varied mammalian and avian herbivores that characterised South America through much of the Cenozoic where advanced mammalian carnivores were almost lacking.

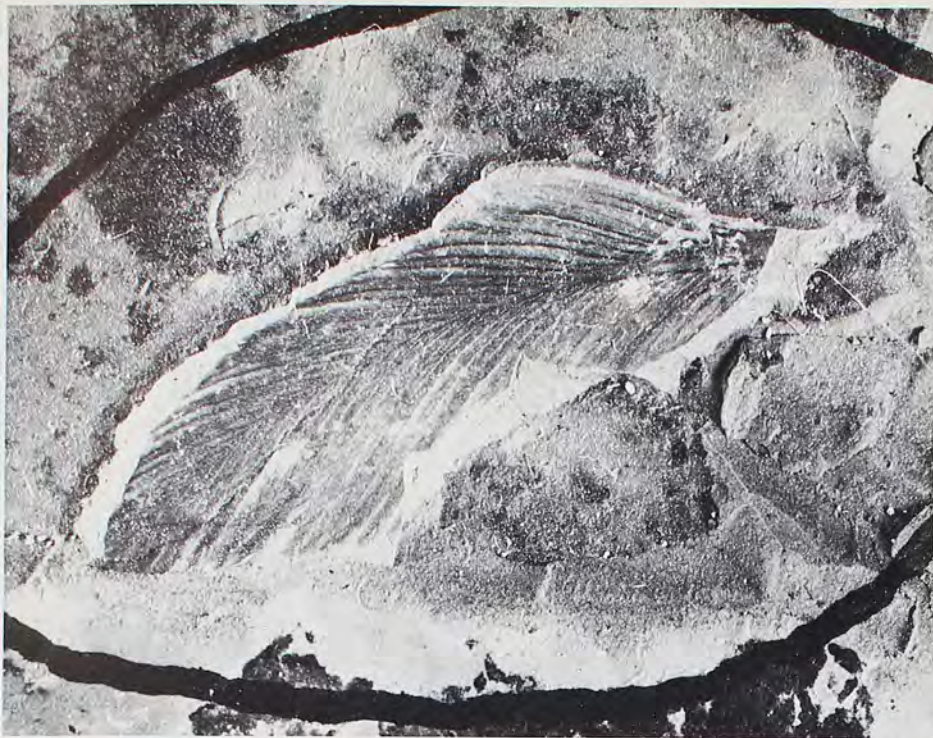
Shorebirds, likewise, were represented by numerous types, many of quite archaic design. *Presbyornis* is a particularly intriguing type. Although placed in a distinct family restricted to the Eocene, it shares many characteristics with ducks and flamingoes as well as the shorebirds (Feduccia, 1978). On the basis of the bill, *Presbyornis* appears to be a duck; the naso-frontal area of the skull is typically flamingo; while the tarsometatarsus (the bone just 'footward' of the drumstick) is most similar to that of a shorebird — all of which again demonstrates the difficulty of identifying the avian 'mosaics'. Such problems characterise the early history of birds, particularly if only one bone or only a fragment thereof is available, as is very often the case. *Presbyornis* is represented by enormous concentrations of bones in the lake sediments of the Green River Lake system of Utah and Wyoming, USA, a system interpreted to be very similar to conditions in the present East African Rift Valley so well displayed in Kenya. Climatic conditions were different from those present in today's Wyoming and Utah, and were in fact, tropical, providing adequate rain for tropical plants, crocodiles, and a number of primitive primates, all suggesting that forests surrounded the lakes. In this environment, *Presbyornis* seems to have played much the same role as living flamingoes and probably had similar colonial nesting habits.

Owls of both ancient and modern design overlap in time during the Eocene. The ancient owls belong in either the family *Protostrigidae* or a new family presently being described, while the advanced forms have been placed in the living family, *Strigidae*, today containing the Boobook, Great Horned Owl and their relatives. By the end of the Eocene, the archaic owls had become extinct, and the nights probably would have been graced by many of the same lonesome calls we hear today provided by these nocturnal hunters.

The Aegialornithidae, a group of birds whose affinities have been controversial during the past decade, were also living during the Eocene. They appear to be related to the nightjars and their relatives and are known from only a very short period of time in France. No further record of the nightjars or their close relatives is known until the Miocene.

Somewhat surprisingly, the songbirds *Passeriformes*, are unknown until much later, in the Miocene; some erroneous records have been cited for the Eocene. The forms abundant and varied at this time, and which may have filled some of the feeding niches of songbirds, were related to woodpeckers in the family *Primobucconidae*, all small land birds present during much of the early Cenozoic. The Eocene would most certainly have been without the dawn chorus so characteristic of today and would have lacked the variety of complex songs offered by the living passeriforms, which we all take for granted as background music of our world.





### Effect of Moving Continents on Avian History

One should realise that the world has not always been the same. At the end of the Cretaceous, for instance, continents probably had a very different arrangement with regard to each other than they do today or in the Jurassic or Oligocene.<sup>3</sup> Such dynamic factors must be kept in mind when trying to understand bird distributions or evolutionary patterns. The similarity of North American and European ground birds (such as *Diatryma*) during the early Cenozoic is nicely explained by the terrestrial connection across the North Atlantic then present. The uniqueness of the South American and Australian records is likewise well explained by the continental drift model. During the late Jurassic, when *Archaeopteryx* was alive, all the continents were closer to one another than they are today, and overland dispersal was easier than now; a few small watergaps may have served as barriers. Global reconstructions have led many scientists to speculate that birds such as the ratites, the gamebirds, and many others might have taken advantage of this situation, and their modern distribution reflects, in part, this ancient geography. Considerations like these complicate interpretation but probably more closely approximate reality.

### Miocene Beginnings of the Modern World

Not until the Miocene (about 22 million years ago) did modern birds become the predominant element in avifaunas and probably for the first time avian song became a noticeable addition to the grunts and cries that had come before. Although birds of Miocene age can be placed in living families, they never-the-less represent distinct species or even genera, now extinct. Forms such as the Australian Dromornithidae, including probably the largest ground birds of all times, may represent groups with a more extensive, but unrecorded earlier history (see Rich and van Tets, 1976). The 'modern' assemblage of

Miocene birds is evidently only the culmination of a long period of avian evolution, that had produced a whole variety of unexpected forms totally unlike the modern birds occupying Darwin's country-side garden or even the slag heaps of the Galapagos Islands. Many of these long extinct forms, however, add substance to Darwin's theory of evolution as well as a marked depth to our own understanding of the feathered 'dinosaurs' which we, today, call birds.

Two kinds of feathers from Cretaceous lake deposits near Koonwarra, southern Victoria, that represent a very ancient record of birds. The feathers are small, only 2-3cm long.

#### ACKNOWLEDGEMENTS

Thanks are due to many people who helped in the preparation of this article; to C. Armstrong for typing, G. Earl for drafting, and the many people and organisations who gave permission for use of illustrative material. Special thanks go to Dr Pierce Brodkorb and Dr W.E. Swinton, whose cataloguing and synthetic work on fossil birds has been most helpful.

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<sup>3</sup>See map printed *Aust. Nat. Hist.* 18(9): 338-341, 1979.



# STALLIONS OF THE SEA

BY ROGER STEENE

Of all diverse organisms inhabiting the world's seas, perhaps none other has captured man's fancy to the same degree as the seahorse, and its close relatives. Our fascination in these creatures is reflected in the writings of scholars dating back to the time of ancient Greece. Much early seahorse literature was devoted to various alleged medicinal properties. For example, the ashes of seahorse mixed with oil and applied to the skin was a recommended cure for a host of maladies ranging from baldness to leprosy. In addition, the midsection of the animal when boiled with wine was reputed to produce a powerful poison.

Today most of these legends have been dispelled, but nevertheless the intrigue which has long surrounded seahorses and their relatives remains.

Although a true fish, the seahorse bears little resemblance to its piscine relatives. Like other fishes it does possess gills for breathing and fins for swimming, but most resemblances end here. Perhaps the most peculiar feature is the odd-shaped head, not unlike that of a horse, and which of course is responsible for the common name. The body is completely encased within a bony exo-skeleton divided into a number of clearly visible ring-like segments. Often there are bony knobs or spikes associated with the segments and in some species there are weed-like appendages. The fins are greatly reduced compared with most fishes, and this accounts for their extremely poor swimming ability. The pectoral (located on the 'neck') and the anal (near the vent) fins are only rudimentary and locomotion is achiev-

This spectacular pipefish, *Halicampus macrorhynchus*, was recently collected on the northern Great Barrier Reef.

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R. H. Kuiter





ed primarily by means of the dorsal fin, which is positioned in the middle of the back. As if these peculiarities were not enough the tail is prehensile, enabling these creatures to anchor themselves to strands of seaweed, coral, or other objects. Pipefishes are anatomically very similar to seahorses and in fact are included in the same family. Basically they can be thought of as seahorses which have been straightened out and which swim in a horizontal position rather than a vertical one. Both seahorses and pipefishes vary greatly with regards to size. Most are between about 2cm and 15cm in length, but a few pipefish and the Australian seadragons which are

discussed below may reach nearly 50cm.

Perhaps more unusual than the bizarre appearance of these fishes is their extraordinary reproductive behaviour. At spawning time the female deposits her eggs (numbering anywhere from 50 to more than 500) in a special abdominal pouch on her mate. Consequently, the 'hapless' male is burdened with the responsibility of motherhood. A sort of 'placental' tissue develops around each egg resulting in a honeycomb appearance if the brood pouch is viewed with the overlying folds pulled apart. After hatching the larval fry remain in the male's pouch and continue their development until the yolk sac of each larva is

The ghost pipefish, *Solenichthys sp.*, bears a resemblance to the seahorse family and is in a separate related family. It lives in the vicinity of tropical reefs.



R. C. Steene



nearly exhausted. The gestation period generally ranges from thirty to fifty days and during birth the male expels the young from its pouch by forcefully twisting and turning . . . a performance which has prompted some observers to liken the process with the labour pains of human mothers.

Another feature common to all seahorses and pipefishes is the tubular snout which varies greatly in length depending on the species. This snout is part of a highly interesting feeding mechanism which works something like a medicine dropper and enables these fish to suck in minute crustaceans with lightning rapidity; the gill plates are forcefully expanded, creating a powerful suction action into the small mouth at the end of the tube. Seahorses are reputed to have a voracious appetite, particularly the young. The late Dr Earl Herald, a world authority on seahorses and pipefishes, and formerly curator of San Francisco's Steinhart Aquarium, estimated that a single two-week old seahorse was capable of consuming 3,500 baby brine shrimp during a ten hour period!

Scientists group the seahorses and their close relatives, the pipefishes, in a single family known as the *Syngnathidae*. This assemblage is relatively large, imperfectly known and the subject of continuing taxonomic

studies. There are approximately thirty species of seahorses and nearly all of these are included in the genus *Hippocampus* (Latin meaning 'horse-monster'). The pipefishes, on the other hand, are an extremely complex group with perhaps as many as 175 species belonging to more than thirty five genera. The members of the family are distributed around the globe, being confined primarily to the vast area lying between 40° latitude north and south of the equator. As with many fish families, the greatest number of species is to be found in the Indo-West Pacific. Australia is particularly well endowed with about fifteen seahorse species and more than sixty pipefish species. Indeed, the 'land down under' has more species than any other similar-sized region in the world.

Australia is also the home of very special seahorses, known as sea dragons, world renowned for their incredible shape and coloration. No book or article dealing with the fascinating subject of protective resemblance (mimicry) in animals is complete without an illustration of the Australian Leafy Seadragon *Phycodurus eques*. Although confined to a relatively narrow stretch of water along the southern coast of Australia, the fish is widely known; for example in Germany it is called *Fetzenfisch*

Continued page 405.

Close-up of the head of a young leafy seadragon, *P. eques*, (total length 15cm).





# CENTREFOLD No. 3

## Fat-tailed Dunnarts, *Sminthopsis crassicaudata*

This attractive little animal, like many of its relatives is often termed 'marsupial mouse'. It is not a mouse at all, although it has a superficial likeness in size and appearance to a house mouse, the head and body measure 9cm, the tail is considerably shorter at 5cm. Its alert and 'foxy' little face, large black eyes and large oval ears combine to make a character which may well have stepped out of a child's story book.

These delicate, soft-furred mammals are marsupials and belong to the family *Dasyuridae*\* which contains a variety of carnivorous animals such as native cats, Tasmanian devils and several small insectivorous forms. It is possible that the thylacine or Tasmanian wolf also belongs in this family.

All dunnarts belong to the genus *Sminthopsis* of which there are about a dozen species which fall into two groups: thin-tailed and fat-tailed. The fat-tailed subject of our centrefold is *Sminthopsis crassicaudata*, perhaps the most widespread of the group. *S. crassicaudata* can be found in southern Australia from Western Australia across the Nullarbor to south eastern areas of South Australia, north to south-east Northern Territory, to the Queensland border in south west Queensland, New South Wales and western Victoria. They live in dry areas—open grasslands, woodlands and stony desert places—where the fat stored in the base of the quaint spindle-shaped tails serves as food storage for lean times. The diet consists of spiders, beetles, crickets, grasshoppers, lizards and frogs. Field studies show that this little animal is largely insectivorous. They build grass nests at the end of a simple tunnel, excavated beneath a rock. Although they live in dry to very dry areas, they need regular access to water.

Fat-tailed dunnarts may be recognised by a dark triangular head patch, the rest of the head and body is silver-grey in colour and its belly is a paler shade.

They are quite common in their range and have been extensively studied in the wild and in captivity. Breeding starts in July and continues until February, over which period one or two litters are produced. Litter sizes may vary in number from one to ten. Entirely nocturnal, these tiny marsupials emerge from their burrows at dusk and return at dawn having spent almost the entire time away in a hunt for food—they rest from time to time during active periods, always in a refuge which gives protection from predators.

Despite the delicate appearance of these tiny marsupials they are fierce predators and can kill and eat animals equal in size. When food is short, usually during winter months fat-tailed dunnarts are capable of entering a state of torpor—mild hibernation—which acts as an energy saver.

\* See page 404 for information on naming animals



Fat-tailed Dunnarts, *Sminthopsis crassicaudata*, are a species of the smaller marsupial carnivores. (Photo: I. R. McCann printed by courtesy National Mammals Index).

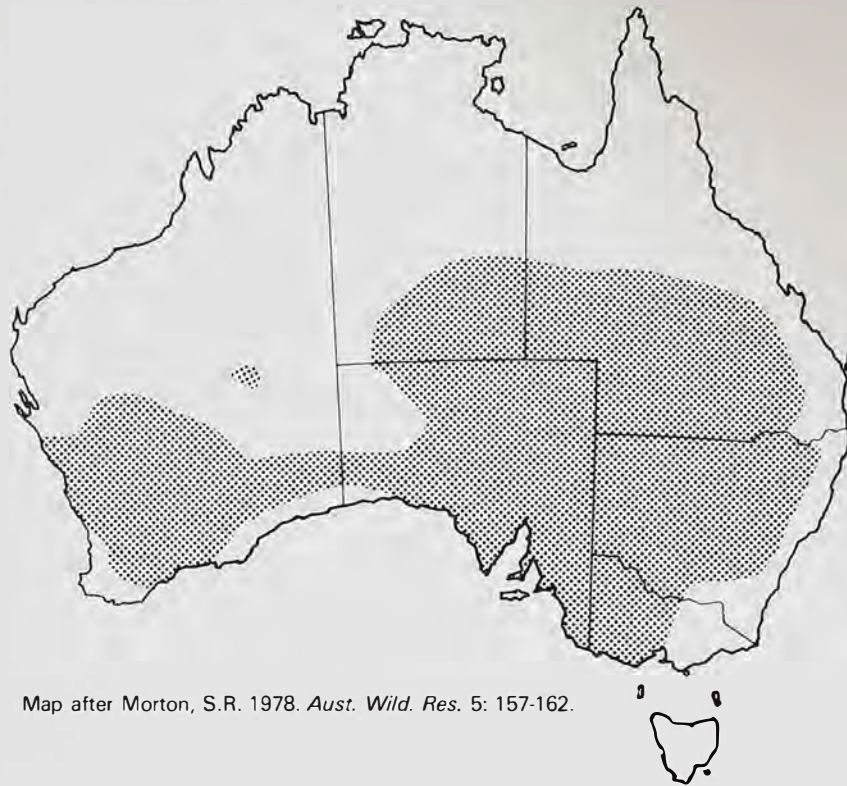








Fat-tailed Dunnarts are plentiful and cover a wide range of Australian dry areas, as this map shows. These marsupials are distinguished from their close relatives by their narrow hind feet.



Map after Morton, S.R. 1978. *Aust. Wild. Res.* 5: 157-162.

## NAMING ANIMALS

All living things are divided into kingdoms of which the kingdom of animals is but one. Kingdoms are divided into groups—called phyla, each phylum is divided into classes, each class into orders, each order into families, each family into genera, each genus into species, a particular kind of living thing. Such a system of naming helps correctly to identify every specimen mankind meets. The name of each species consists of two words, the first being the name of the genus (something like a person's surname), the second designating the species as people have a given name.

For further accuracy Latin forms are used: Latin forms are understood throughout the world. Common names vary from country to country, even from locality to locality and very often are not at all accurate. Each kingdom has thousands of different sorts of living things and there are further sub-divisions but those given here are the main categories.

To help the student and others new to the field of natural history our centrefold subject will always be accompanied with a range map and a classification which will give the order, the family, the genus and species of the animal illustrated. Whenever possible the most widely used common name will be included.

Order: Marsupialia  
Family: Dasyuridae  
Genus: *Sminthopsis*  
Species: *Sminthopsis crassicaudata*  
Common name: Fat-tailed Dunnart.



and in Italy *Cavalluccio flatterice*. Leafy seadragons do not appear to be particularly rare, but because of their extremely effective camouflage they are virtually invisible underwater. Basically they have a seahorse shape, but there are numerous leafy appendages on the head, body, and tail which closely resemble the kelp amongst which these animals live. Because of its cryptic habits and disguise par excellence, few people have had the pleasure of observing this remarkable animal in its natural habitat. Consequently, until recently there has been a paucity of information regarding their natural history.

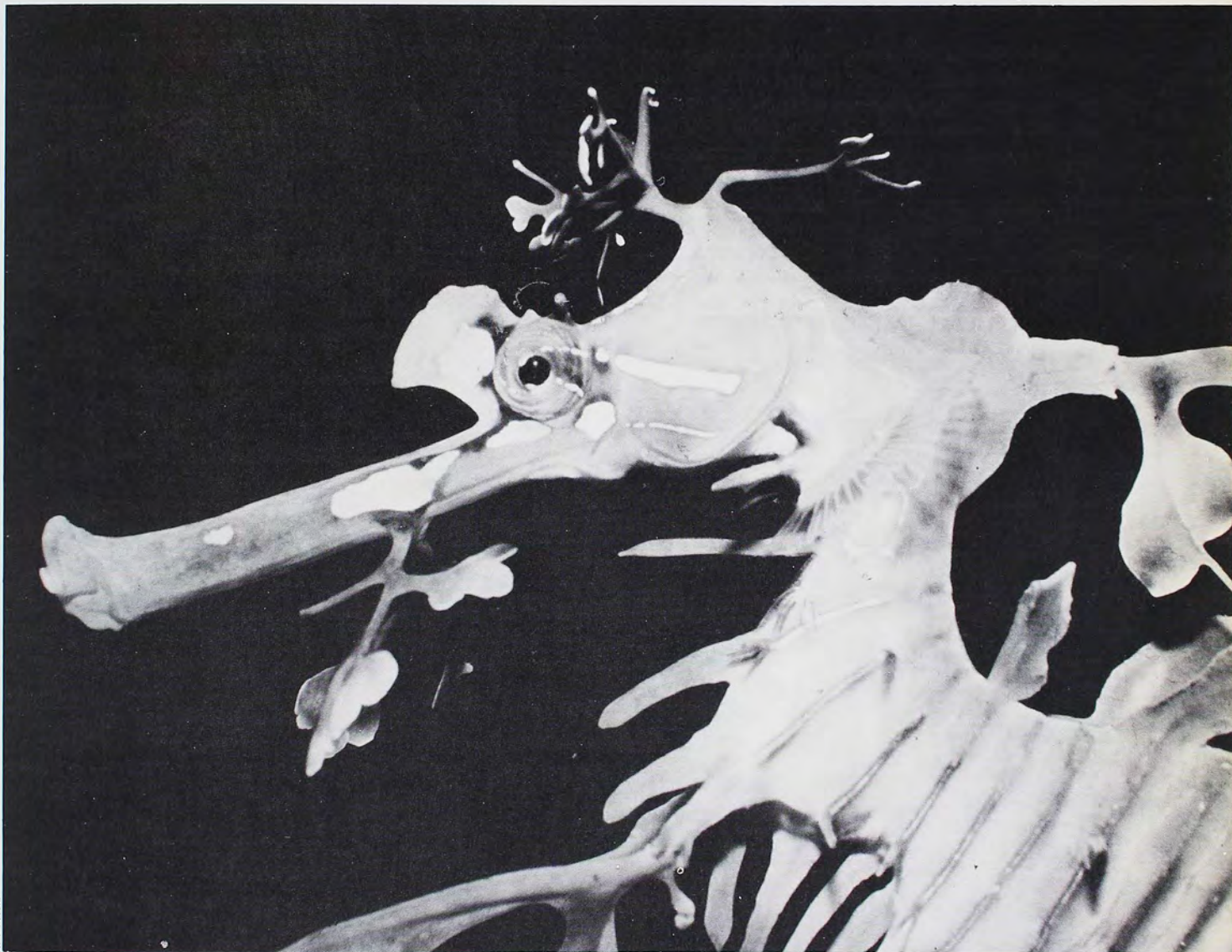
Most specimens now lodged in the world's museums were collected by trawl or were found dead on southern Australian beaches after storms. However, all this is now changing due largely to the efforts of Rudie Kuitert, an amiable Dutch immigrant who lives in Sydney. Although an electronics engineer by trade Rudie has long been a keen diver and photographer, and his ability to collect live fishes underwater with a hand dipnet is almost legendary among Sydney aquarists. More recently, he has been made an Honorary Associate of The Australian Museum and has co-authored several scientific papers. Rudie's main passion at present is the classification and biology of seadragons and it would be safe to say that

no other person has been so successful when it comes to finding these creatures in their native habitat.

Earlier this year I had an opportunity to make several dives with Rudie at the Recherche Archipelago, a chain of rocky outcrops located off Esperance, Western Australia, near the western edge of the Great Australian Bight. I eagerly accepted an invitation to join a fish collecting expedition to the archipelago extended by Dr Gerald Allen, Curator of Fishes at the Western Australian Museum in Perth. As an underwater photographer I particularly relished the thought of this trip. First and foremost in mind were the Leafy Seadragon and the Blue Devil *Paraplesiops meleagris*; family Plesiopidae, two of the most magnificent photographic subjects in southern Australia. The latter species was reported to be common in the Esperance area and I was confident of capturing it on film, but as far as the seadragon was concerned Lady Luck would have to play a major role. However, when I discovered Rudie Kuitert was to join the expedition it seemed certain that if seadragons were present in the area we would locate them.

During the first week we explored Lucky Bay, adjacent to our camp on the mainland, and made daily forays out to some of the nearby islands. Despite our searching we

The tube-like snout and unusual head shape of this *P. eques* are features shared by all seahorses (total length 35cm).



R. C. Springer



failed to find a single dragon, but this was without Kuiter's assistance. As it turned out Rudie was unable to join us until the last few days. As he was donning his gear for the first dive at Lucky Bay I half jokingly suggested that he bring me back some live dragons to photograph. Rudie just grinned, but, lo and behold! two hours later he returned with a fine adult specimen of the Leafy Seadragon and two Weedy Seadragons *Phyllopteryx taeniolatus*, a colourful relative which lacks the magnificent appendages of *Phycodurus*. The next day Rudie led us to several more and two delightful hours were spent at the bottom of Lucky Bay taking the photographs featured in this article.

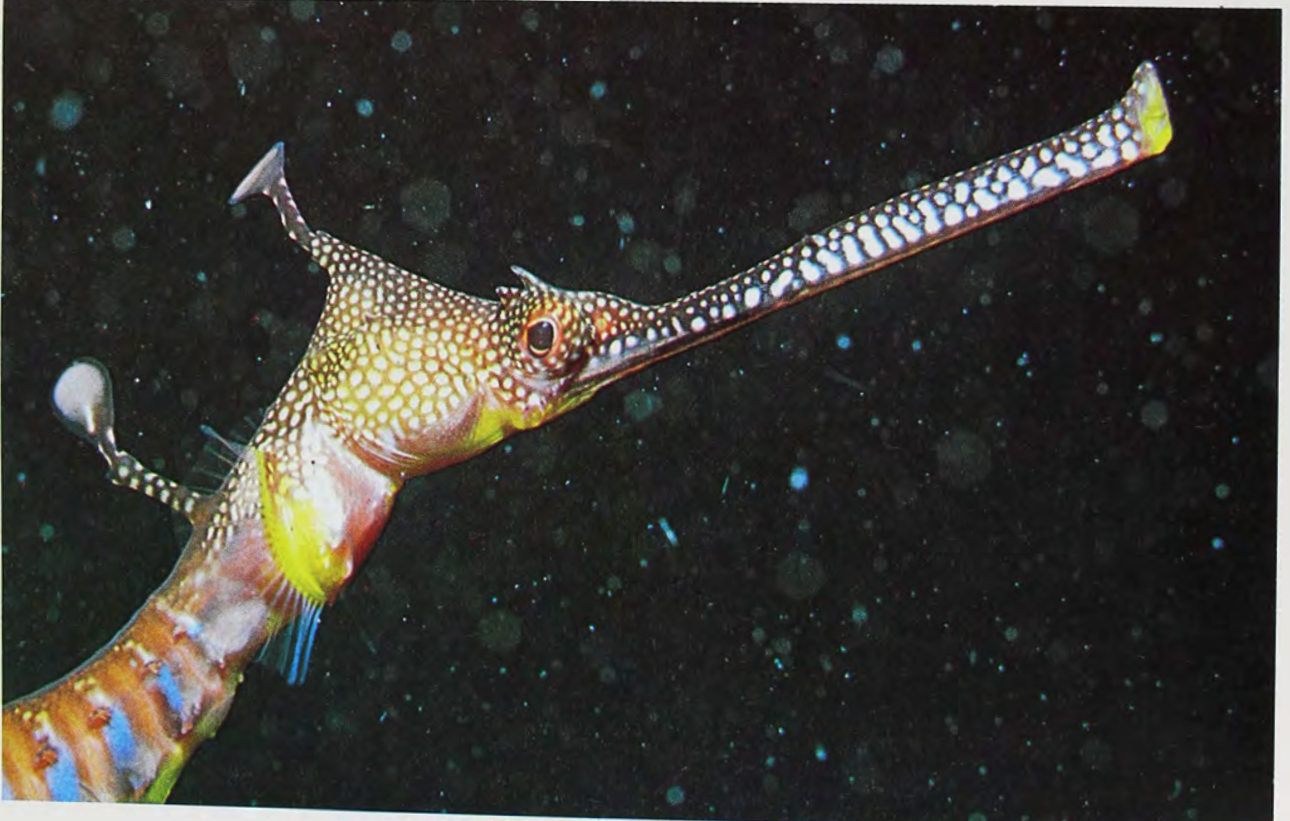
Seadragons have a reproductive biology which is similar to that of seahorses except the male lacks a brood pouch. Instead, the eggs are fastened to a modified patch of skin on the underside of the tail. Both species of seadragons inhabit rocky reefs which are overgrown with kelp and other forms of seaweed. The preferred depth generally ranges from about five to twenty-five metres. They are frequently found in close proximity to the base of kelp stalks and exhibit little movement except a swaying motion in unison with the weed as a result of currents and swell. Once sighted and approached by a diver they show almost no concern for their own safety and must be pushed and prodded before making any attempt to escape. Locomotion is mainly achieved by rapid undulations of the dorsal and pectoral fins, but because of their awkward shape and reduced finnage, the swimming speed is comparable to a slow crawl. In fact these fishes are so slow that they are easily captured bare-handed without the aid of a net. Seahorses and pipefishes do not require great bursts of speed to escape would-be predators. Instead reliance is placed on the bony, unpalatable exoskeleton, and in the case of the

Close-up of the head of an adult weedy seadragon, *Phyllopteryx taeniolatus*, unique to Australian seas. (total length 25cm).

R. C. Steene



R. C. Steene







R. C. Steene

Leafy Seadragon, its uncanny resemblance to kelp. However, complete predator immunity is never achieved by any member of the animal kingdom. Seahorses have been found in the stomachs of sharks, rays, and a few other fishes such as the South African Blacktail *Diplodus*.

Ghost pipefishes are another unusual group inhabiting Australian seas and adjacent areas in the Indo-Pacific. Actually they are not true pipefishes and scientists place the approximately six species in a separate but related family, the Solenichthyidae. Although the basic body shape and segmentation is similar to the pipefishes they differ markedly with regards to the size and structure of the fins. Instead of a single dorsal fin as in syngnathids, they have two dorsals, the first of which is relatively elongate. The caudal, anal, and pelvic fins are also well developed and there is a pair of stubby pectoral fins, just behind the head. In spite of this increased finnage the ghost pipefishes are poor swimmers at best and rely mainly on their cryptic coloration and bony outer skeleton for protection. Unlike seahorses and pipefishes the female handles the chore of egg incubation. She has specially modified pelvic fins which are joined together to form a brood pouch; male pelvic fins are normally developed and free from one another.

Certainly the seahorses, pipefishes, and ghost pipefishes must rate among mother nature's most unusual creations. Few other fishes can boast so many peculiarities . . . a horse-like head, coat of armour, and a kangaroo pouch to name a few. Small wonder these incredible 'Stallions of the Sea' have aroused man's curiosity through the ages.

#### FURTHER READING

Whitley, G.P. and J. Allan. *The sea-horse and its relatives*. Georgian House, Melbourne, 1959.

Adult leafy seadragon, *Phycodurus eques*, glides majestically over the seascape at the Recherche Archipelago of southwestern Australia. (total length 30cm).

Head of *Hippocampus* sp.





# SEA MONSTER IN OPAL —or the one that got away?

BY ALEX RITCHIE

Top: Hauling the plesiosaur specimen up the shaft of the opal mine. Centre: Preparing to haul the plaster-jacketed trunk of the plesiosaur skeleton up the shaft to the surface. From right to left: Robert Jones, Technical Officer, The Australian Museum; Ken Harris, White Cliffs and an opal miner friend of Mr Harris. Bottom: White Cliffs from the air: Part of Sullivan's Hill, Ken Harris' opal mine where the plesiosaur skeleton was discovered in 1966 is in the centre, distinguished by the high, conical tip of opal dirt.

One day in mid-July 1976 the phone rang. "I have a call for you from White Cliffs," said our switchgirl, immediately arousing my attention. White Cliffs, in far western New South Wales, is world-famous as one of Australia's main sources of precious opal. The most likely reason why someone would phone me from so far away was that some unusual fossil specimen had turned up and they wanted advice. "My name is Ken Harris" said the caller, "I'm an opal miner at White Cliffs. While I was sinking a new shaft I came across something that appears to be a skeleton in the rock. Can someone there come out and look at it and maybe advise me on how to get it out?"

A few questions soon convinced me that Mr Harris really had come across a genuine skeleton and that it was partly or completely replaced by opal. It appeared he had first seen the opalised bones in the side of his shaft and that he had then dug into the wall to uncover most of the upper surface of the skeleton which was around 2m long. At this point, sensibly realising that the task of getting the fragile skeleton out of the rock was a difficult one and best left to specialists, Ken Harris covered up the specimen carefully and called The Australian Museum for assistance and advice.

Such calls come only too infrequently in a Curator's career; more often a fossicker or miner comes to the Museum, pours a heap of miscellaneous fragments on the desk and expects the scientist to reassemble and identify them. Ken Harris had done just the right thing in the circumstances and I assured him I would get out to White Cliffs as soon as possible. A quick request to the Director of the Museum produced the necessary approval, a four wheel drive vehicle was immediately available and after spending two days purchasing provisions

and organising camping and digging equipment we were ready to leave.

Mr Robert Jones, Technical Officer in the Department of Palaeontology accompanied me; his task would be to carry out the delicate preparation of the fossil when we brought it back to the Museum. We headed west across the Blue Mountains towards the dusty western plains. White Cliffs lies some 800km WNW of Sydney and about 80km north of Wilcannia, a small town on the River Darling. It took the best part of two days driving to reach the opal field. We eventually tracked down Ken Harris at his underground home (a disused opal mine), I was hoping that the whole thing wasn't a false alarm. On an earlier occasion an emergency collecting trip to far western Queensland was undertaken to investigate a reported dinosaur skeleton which proved only to be an unusual weathering phenomenon in sedimentary rock and not a skeleton at all!

In Ken Harris' case however I had a fairly good idea what he must have found before I actually saw it. On several occasions since the discovery of the Australian opal fields in the late 19th century incomplete fossilised skeletons of long-extinct marine animals have turned up in the opal-bearing sedimentary rocks of White Cliffs in New South Wales and in the contemporaneous formation in the South Australian opal fields at Coober Pedy and Andamooka. Most of these have been skeletons of plesiosaurs, marine reptiles which roamed the world's oceans during the Age of Dinosaurs in Jurassic and Cretaceous times, between 180 and 70 million years ago. Skeletons of such animals are not uncommon in many parts of the northern hemisphere and numerous museums there have superb, complete plesiosaur specimens in their public displays and scientific collec-

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ALEX RITCHIE is Curator of Fossils at The Australian Museum. His principal research interest is the early evolution of fishes, particularly those of Ordovician, Silurian and Devonian age.



tions. Only in Australia are these skeletons preserved in such a way that the original bone has been partly or completely replaced by opal but no museum in Australia to date has been able to acquire a complete opalised skeleton.

There are several reasons for this. Few opal miners have been sufficiently aware of the existence or scientific importance of such finds to excavate them with the skill or care they require. In most cases the bones have been dug out piecemeal and have often, through ignorance or financial necessity, been broken or cut up in search of gem quality opal. In fact whilst such opalised bones may consist of precious opal more often it is only common opal, either clear as a jelly or a milky white patch, which has taken the place of the original bone.

The process by which this replacement occurs is still not fully understood. The fossil remains which most frequently occur in opalised condition are the bones and teeth of reptiles, the shells of marine molluscs (bivalves and cephalopods), the stem and cup plates of crinoid (or sea lily) skeletons and lumps of ancient wood.

The fossil remains found in the outback opal fields of Australia show quite clearly that around 100 million years ago the central part of the continent was covered by an enormous shallow sea inhabited by a wide range of marine organisms. The plant and animal remains, which eventually became opalised, were first buried in soft sea floor sediments and later turned to rock by deep burial and great pressure. Many millions of years later the fossil-bearing rocks were brought back near the surface by natural processes of uplift and erosion. When these formations came within reach of groundwater circulation natural acids in the water leached away or dissolved the original bone, shell or petrified wood to leave behind a cavity or natural mould.

Into such cavities percolated groundwater solutions rich in dissolved silica forming a colloidal solution or



A. Ritchie



A. Ritchie

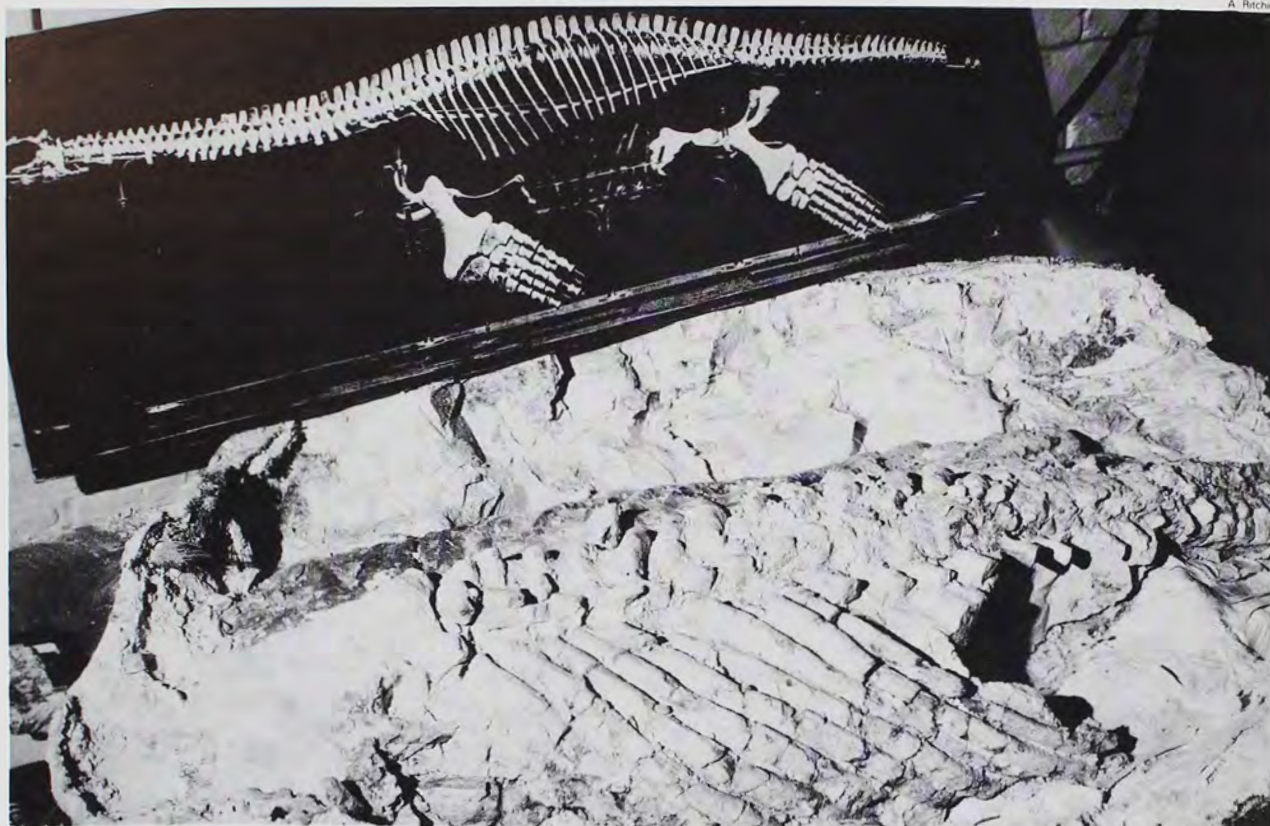




silica gel. The silica in turn may well have been derived from the innumerable, minute, siliceous skeletons of ancient marine micro-organisms preserved in the surrounding Cretaceous sediments. This silica gel filled all natural crevices including the natural moulds of the fossils and slowly solidified with a very distinctive micro-structure being developed. This consists of extremely small, tightly packed and regularly arranged spheres. The spheres act as a diffraction grating breaking up white light into its component colours and providing the distinctive optical effects of precious opal in a small proportion of the siliceous deposits.

The odds against any particular organism being buried and preserved as a fossil are enormous. The odds against the same fossil being subsequently discovered and its significance recognised are almost astronomical. For this reason science is indebted to members of the

When we reached his new shaft, near Sullivan's Hill, Ken explained that he had driven his first passages in from about the 5-6m deep level which was generally believed to contain good opal. Not finding this layer very productive he had then decided to deepen the shaft to around the 12m level to reach another possible opal layer. Halfway between the two, and at a level where opal is not commonly found, Ken noticed a flash of colour in the side wall and picked around it carefully to see how far it extended. To his surprise he discovered that it continued for some distance as a series of separate pieces of approximately equal size. It was only then that he realised he had discovered a fossilised backbone of some largish animal whose bones were completely replaced by varieties of opal, mostly of the non-precious types. By a stroke of good fortune the skeleton lay just near enough the shaft wall to be visible without being



A. Ritchie

public who find and report such discoveries to the proper authorities for scientific investigation. The discovery of the latest opalised plesiosaur skeleton from White Cliffs reflects greatly to the credit of Ken Harris who found and reported it to the museum.

Ken filled in the details of the discovery as we lunched with him in his cool underground home where he lived with his wife Orme and their young family. He then guided us through the maze of tracks past innumerable crater-like structures which surrounded worked out shafts sunk in search of precious opal. From the air White Cliffs presents an incredible sight, looking more like a heavily cratered region of the lunar surface than a mining centre in outback New South Wales. There are said to be over 11,000 separate shafts sunk in the White Cliffs field, most of them crammed in an area about 3.5km long and about 1.5-2km across.

destroyed. Had it lain several centimetres to one side it would have been missed completely. On the other hand had it lain one metre in the other direction it would almost certainly have been destroyed, or at least seriously damaged, by the pick and jack-hammer used to break up the floor during the shaft sinking operation.

It did not take long to confirm our suspicions—Ken's find was a skeleton of a plesiosaur and this particular specimen was of a smallish individual measuring as far as we could judge, about 2.5m from head to tail. The skull appeared to be present and, although crushed, still in place at the end of the long, slender neck, a rare occurrence in Australian plesiosaur finds. In the body region we could see various portions of ribs exposed and, to one side, some of the upper limb or paddle bones (the equivalents of our humerus and femur). Ken had searched around the specimen carefully but had

Trunk skeleton of the opalised plesiosaur under preparation in The Australian Museum, Palaeontology Laboratory, September, 1976.

Some of the rear ribs on the left side have been removed for repair and construction. In the background is an illustration of a similar specimen, *Cryptocleidus*, in the Natural History Museum, London.



found no trace of the smaller paddle bones (equivalent to those of our fingers) which may well have fallen or been bitten off before the skeleton finally sank to the bottom of the sea around 110 million years ago. The tail also appeared to be missing. For security reasons Ken Harris had told very few people of his find. We decided to camp right beside Ken's shaft while working on the skeleton lying 8m below ground.

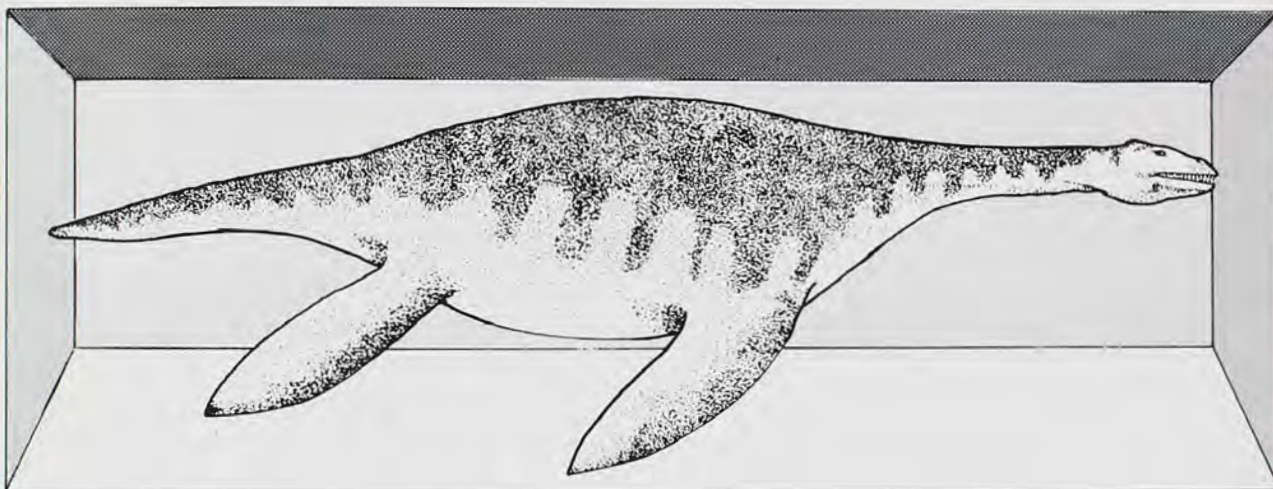
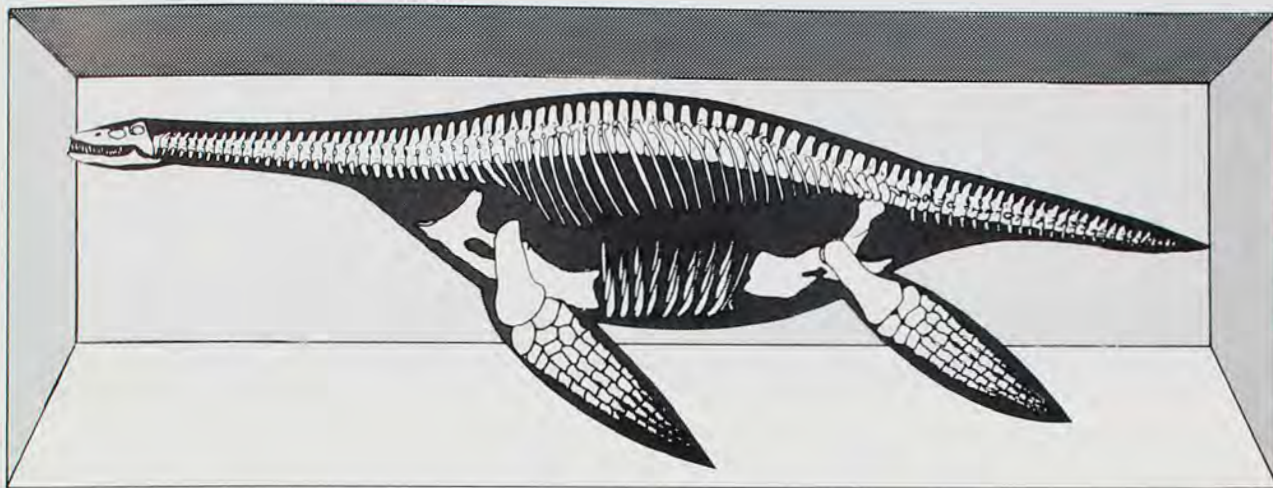
Underground it was pleasantly cool and we worked away with small chisels, probes and brushes to clear away as much of the overburden as possible. Having established the lateral extent of the skeleton we then dug away the surrounding rock to leave it sitting up on a low pedestal. Working through the day and into late

supply ran out. Batches of plaster were mixed up in a plastic basin and plaster-soaked hessian strips were applied to the surface of the fossil, crisscrossed to give added strength as they set rock hard.

The upper surfaces of the skull, neck and trunk sections in turn were encased in several layers of this material after which the underlying rock was slowly and carefully undercut and additional strips plastered to the underside. The skull region was removed first, turned over and plastered on the reverse to enclose completely the fragile opalised bone still in its original matrix. The metre long neck section was more difficult but was extracted in one block without damage.

Then came the moment of truth! The largest section

Artists impression of how the White Cliffs opalised plesiosaur might be reconstructed and displayed. Half of the skeleton, with the missing or damaged parts modelled up (fine stipple) could be mounted with half of a life-size model showing the animal as it may have appeared in life. In this way two superb display items could be obtained from the one original skeleton.



G. Ferguson

evening we reached a stage where it was certain no detached bones lay in the immediate vicinity of the skeleton. We then started to jacket it in plaster using a technique widely used for the recovery of delicate fossil skeletons.

For safety and more convenient handling we decided to divide it into three sections—the skull, the neck and the trunk. Each section was covered first with layers of toilet paper, dampened with water and moulded onto the surface of the fossil. This acted as a separation layer between the fossil and the plaster jacket. The next stage was to tear up or cut innumerable strips of hessian. We had taken with us a large quantity of plaster of paris and Ken Harris provided a bag of builders' plaster when our

of all, containing the entire trunk, was slowly undercut until it rested on a narrow pedestal. When, eventually it could be rocked free of its base it took three of us, pushing and pulling in the confined space, to roll it over. As we did so, many blocks of the matrix dropped out but none, fortunately, containing any part of the skeleton. Before the final covering of plaster and hessian was applied Bob and I removed as much as possible of the remaining rock around the skeleton to reduce the weight to a minimum. The casts were then left to harden overnight.

The following morning it was a relatively easy matter to haul the skull and neck casts to the surface but the massive trunk section, one metre across, had to be





B. K. Jones

Dr Alex Ritchie, Curator of Fossils, The Australian Museum, plastering the neck section of the opalised plesiosaur skeleton, prior to its removal.

winched up very carefully, keeping it clear of the sides of the narrow shaft. Once safely on the surface the specimens were quickly transferred to the Museum's long-wheelbase Landrover and, as an added refinement, Ken Harris produced a rather smelly old mattress rescued from the town dump, to cushion the casts from unavoidable bumps on rough outback roads. With our mission accomplished we left White Cliffs as quietly as we had arrived with possibly the finest opalised skeleton of an extinct marine reptile found in Australia. To the best of our knowledge this was certainly the first plesiosaur to be found here with the all-important skull still attached.

By 23 July, 1976 we had the opalised skeleton safely installed in the Preparation Laboratory of The Australian Museum in Sydney. It was unfortunate we were unable to prepare the skeleton in time for secure display during the International Geological Congress held in Sydney during August when hundreds of overseas scientists visited the Museum.

Work on the casts began in September 1976, when the trunk section was first tackled opening it up from the underside where the skeleton was still largely concealed by rock. Cutting away the plaster jacket Bob Jones started to scrape and brush away the softish clay matrix until one after another the ribs came into view. We soon realised that the plesiosaur had come to rest and had been buried lying flat on its back. The left and right sets of ribs and backbone were found to be virtually complete and in place. All of the bones were well preserved but brittle as glass having been completely replaced by silica in the form of opal. As a result of earth movements during their 100 million year long burial they had suffered many small fractures and broke up readily into small pieces.

While this work was going on we kept Ken Harris fully informed of progress and hoped, naturally, that such a fine specimen of a long-extinct Australian animal would be acquired by The Australian Museum for public display. The preparation and restoration of such an object is a lengthy, technically difficult task involving months or years of painstaking work and the skills of various specialists. Such an opalised skeleton, mounted for permanent display in a place like The Australian Museum would be seen and admired by over 650,000 visitors each year. Not only would it be a marvellous tourist attraction, it would also be of major educational and cultural value.

However, Ken was reluctant to mention a figure and the Museum offer, limited by its resources and the lack of any government acquisition fund, was not acceptable.

Anxious that such a fine specimen should not be lost to the vast majority of Australian and interested overseas visitors I devised what seemed to be a mutually beneficial compromise: The Australian Museum should prepare the entire skeleton, removing it from the rock and cleaning and reassembling all the fractured bones. The skull was irretrievably crushed and the tail and the paddle bones were missing, but these could be modelled up and restored from similar animals found elsewhere. When the skeleton had been reconstructed as a three dimensional structure it could then be sliced in two, lengthwise along the backbone. Our preparators would then make a full-size fibreglass reconstruction of the animal as it must have looked in life and this would also be cut in half. By combining these we could create two fine display items, one with the left side of the skeleton and the right side of the model and the second would be identical but a mirror-image. In this way both Ken Harris





R. K. Jones

and The Australian Museum would have a spectacular, professionally restored display item. The work involved in such restoration would be carried out in return for half the skeleton at a reasonable price within Museum resources.

This proposal also proved unacceptable and shortly afterwards Ken Harris asked us to stop work on the specimen. In October 1976 he arrived at the Museum, packaged up the extremely fragile and partially prepared specimen and took it back to White Cliffs. Since then the opalised skeleton has been in Ken's tourist walk-in opal mine on show to some thousands of visitors, providing him with some supplementary income.

In return for the work carried out by its staff The Australian Museum retains the right to first option of purchase should Ken Harris ever decide to sell.

And there, both the plesiosaur fossil and the matter of acquisition rest . . . !

This is the second such specimen which has slipped away from the Museum in the last decade. In 1970 a woman opal miner from Andamooka, South Australia, discovered, and with the Museum's advice excavated a reasonably complete skeleton in her mine. Assurances were made that the Museum would be given an opportunity to purchase, but later, by chance, it was learned that an American business-man had purchased it for his local Museum in the USA. The specimen is safely preserved under expert care, but it is ironical that a unique specimen of Australia's past has ended up in an American museum when there is no comparable specimen in any Australian museum.

The circumstances surrounding the major Australian fossil discovery at White Cliffs raise many questions of

fossil acquisition which need to be resolved. Such specimens are unquestionably part of Australia's heritage and ought to be acquired by the appropriate state museum for national collections where they will be freely accessible to the widest possible range of Australians and overseas visitors.

Undoubtedly the discoverers and owners of such finds have every right to the best reward possible based on a fair evaluation of the find and of the owner's time and effort. Ken Harris has declared he does not want the plesiosaur to leave Australia and he must surely win support for his outspoken criticism that a country which can afford to pay large sums for controversial cultural items such as 'Blue Poles' or 'Woman V' should be prepared to give at least equal consideration to unique Australian natural history items. The problem however is that whilst opalised skeletons might be extremely popular with a large section of the general population, more so perhaps than abstract art, they are not regarded as 'culture'. Natural history museums, which do so much to enlarge and enrich Australians' understanding of their natural surroundings, have difficulty therefore in obtaining the degree of philanthropic sponsorship which other institutions enjoy.

In the case of an opalised skeleton, even where (as in this case) very little of the opal is of the precious variety, the sum required for its acquisition by the Museum is way beyond its resources. Perhaps I am wrong and there are some philanthropic organisations or individuals in Australia who are sufficiently interested in natural history to save this item for the nation! Or am I correct in suspecting that it may well be destined to be purchased by a Houston millionaire and slipped out of the country — another 'one which got away'?

Part of the neck skeleton of the plesiosaur showing the jelly opal which replaces the original bone. In the background are several detached limb bones.



# LOST TREASURES OF THE GARDEN

BY LISSANT BOLTON, GEOFF O'DONNELL AND JOHN WADE





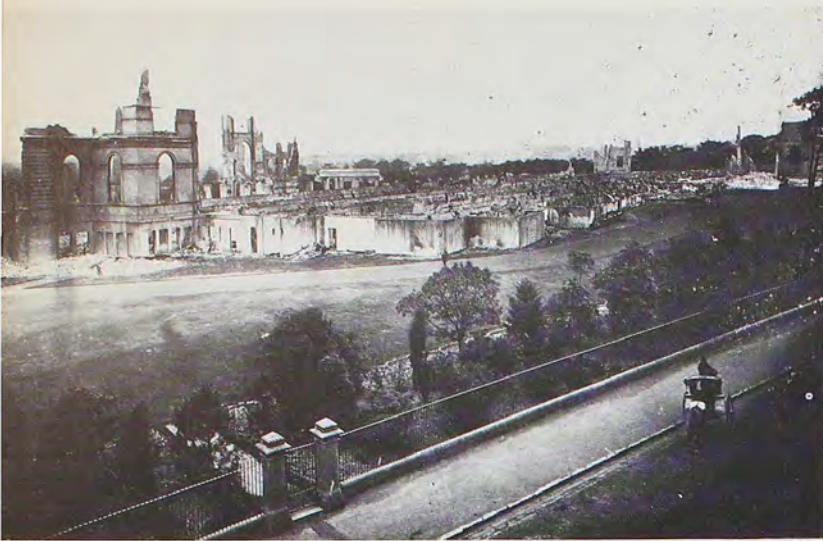
# PALACE

The great International Exhibition, Sydney, 1879-80, as seen from the harbour.



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The destruction after the fire. It is surprising that anything survived.

The year 1979 marked the one hundredth anniversary of the opening of one of the most ambitious and spectacular public exhibitions that Sydney has seen: the Garden Palace Exhibition in the Sydney Domain.

During the nineteenth century, as today, trade and manufacturing exhibitions were a popular form of public entertainment, and engendered an enthusiastic national pride peculiar to the climate of imperial growth. The first and most famous of these was London's Crystal Palace Exhibition, 1851, conceived and sponsored by Prince Albert, the Prince Consort. Its especial splendour created an architectural and social fashion, followed in many

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The Garden Palace set in its thirty two acres of gardens overlooking Farm Cove.



Government Printer

other countries such as Austria, the Vienna Exhibition 1873; the United States of America, the Centennial Exhibition, Philadelphia 1876; and France, the Exposition Universelle de Paris, 1878.

Initiated by the Royal Agricultural Society of the Colony of New South Wales the original concept of the Garden Palace Exhibition arose from the Intercolonial Exhibitions held annually from 1870 in Prince Alfred Park, Sydney. The Inter-colonial Exhibitions were not large scale projects, being composed mainly of entries from the Australian colonies, although Fiji and New Zealand did send entries on several occasions; out of this grew the idea for a larger international exhibition.

Planning for the exhibition was begun in mid-1877 when the proposal was accepted by a meeting of the Royal Agricultural Society. The project was originally foreseen as an international version of the Inter-colonial Exhibitions, and the Royal Agricultural Society elected to finance the entire scheme. However the response from intending exhibitors, both international and local, was so great that the board of the Royal Agricultural Society had to admit that the project was beyond their means and the exhibition was nearly abandoned. Fortunately the President of the Royal Agricultural Society, Sir Hercules Robinson, was at that time the Governor of New South Wales and the newly elected colonial government of Henry Parkes was persuaded to assist.

The Exhibition Committee received Royal Commission from Queen Victoria in 1878. There were twenty-four Commissioners, including the then Curator of The Australian Museum, E.P. Ramsay.

The Prince Alfred Park site was too small for an undertaking of such proportions. The Sydney Domain, opposite the present State Library in the south western corner of the modern Botanic Gardens, was chosen as the site. Late in 1878 The Colonial Architect, James Barnet, was asked to prepare a design and working drawings for the Exhibition.

Construction began in the first week of January 1879. By April the project was behind schedule so work continued at night by electric light, introduced that year for the first time in Australia.

In spite of the late start and other problems, such as a strike by tradesmen, by the beginning of September 1879 the exhibition building itself, the Art Gallery, the Agricultural Hall at the back of the Sydney Hospital and the thirty-two acres of gardens was completed.

James Barnet gives this description of the Garden Palace:

"The plan of the building is cruciform, with nave and transept, supplemented by extensive aisles, and is 800 feet in length from north to south, and 500 in width from east to west. The nave and transept are 50 feet wide and 60 feet high, surrounded by galleries 25 feet wide, lighted from a clear-story, and at their intersection surmounted by a dome 100 feet in diameter, springing 90 feet from the floor, and terminating in a lantern whose finial is 210 feet above the ground, which last is 102 feet above high-water-mark. The dome is lighted by windows in the drum, and an eye 20 feet diameter in the apex under the lantern. The



nave and transept terminate in four entrance towers, each 50 feet square, and varying in height from 120 to 150 feet, according to the fall of the ground. There are also ten minor towers, 25 feet square, varying from 75 to 100 feet in height, surmounted by open lanterns, placed at as many external angles of the building. The extensive aisles are covered with serrated or lean-to roofs, and lighted overhead with vertical windows facing south to avoid direct sunlight. The basement is lighted from lofty side windows."

The grand, solid appearance of the building with its central Renaissance dome and four main towers is somewhat misleading. The foundations, facade and towers were of brick rendered to look like stone. Unlike the Crystal Palace, which was built of glass supported on cast iron columns, the framework of the Sydney building was timber, and the roof, including the dome, was of galvanised iron sheets. There is some evidence to suggest that an iron framework was originally intended, but the pressure to complete the building before Melbourne got its Exhibition Building (planned for 1880) dictated the use of more readily available and workable pine.

The Garden Palace was officially opened by the Colonial Governor, Lord Loftus, on September 17, 1879, only nine months after ground was first broken, and two years after planning began. The building cost £191,800—somewhat more than architect Barnett's estimate of £50,000. Music and poetry were specially composed for the occasion; Charles Badham's motto for the exhibition *Orta recens quam pura nites* (newly risen, how bright you shine) was subsequently adopted by the State of New South Wales and incorporated in its coat of arms in 1906.

Under the central dome, which had a twenty-foot diameter stained glass skylight, stood a bronze statue of Queen Victoria by Marshall Wood, surmounting a fountain with jets and cascades; this became a popular meeting spot. Another feature of the building was the American steam passenger elevator installed in the northern tower, the first of its kind in Sydney.

Exhibits came from Britain, Germany, France, Italy, Austria, Japan, India, the United States and other countries as well as from the six Australian colonies and New Zealand. They ranged from glassware to steam shovels, from sugar cane to minerals, from needlework to paintings. The catalogue listing them runs to over a thousand pages.

The Ethnological Court, in the northern gallery of the eastern transept was opened on November 11, 1879 and included entries from public institutions such as the Australian Museum and from private individuals. The section prepared by the Australian Museum was of special significance because of the large number of specimens involved, over two thousand. For this the Museum was awarded the 'First Degree of Merit' for presenting 'the finest collection (ethnological) in the Exhibition'. Collections were also sent by New Zealand, New Caledonia and Fiji.

The Museum also presented an extensive display of technological models and drawings. These had been purchased in Britain in 1878 by Professor Liversidge on

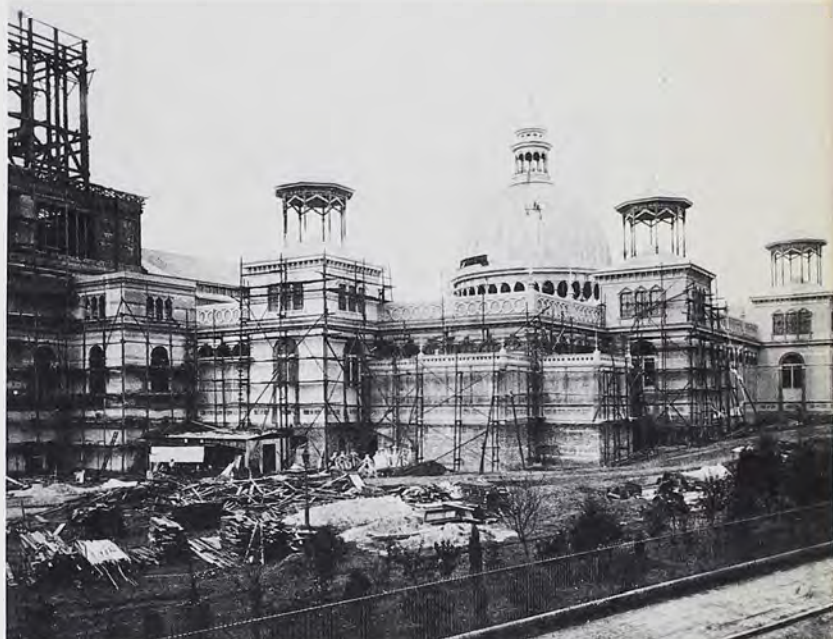
behalf of the Museum and were intended to form the basis of a technological gallery at the Museum after the Exhibition closed.

During the 185 days for which the Garden Palace Exhibition was open, attendances averaged six thousand per day and peaked at twenty-seven thousand on Australia Day 1880, an indication of the outstanding attraction the Exhibition held for the population of Sydney which then numbered only two hundred and fifty thousand. All told, more than a million people visited the Exhibition.

The Exhibition closed on April 20, 1880. Most of the displays were dismantled at that time; however the art gallery collection was kept intact and the ethnological and technological collections belonging to the Australian Museum remained in storage in the exhibition building. The passenger elevator was sold to a Sydney brewery.

Prior to the Garden Palace Exhibition the ethnological collection of the Australian Museum was administered by the Ethnological Committee consisting of Trustees Professor A. Liversidge, Mr R. Hunt and Sir A. Roberts.

The construction site on the 6th August, 1879, six weeks before the Exhibition was opened.



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After the Exhibition closed the Committee continued to manage ethnology and included the expanding technological collection under its brief.

Early in 1880 the Committee, through the Trust, approached the Colonial Government for a vote of funds for a new technological and ethnological branch of the Australian Museum to be housed in the exhibition building.

The Technological, Industrial and Sanitary Museum was formally established as a branch of the Australian Museum in May 1880 when the New South Wales Government gave the Committee of Management the £1,000 which had been voted to it by Parliament. In September of the same year the Museum sought accommodation in the Garden Palace building and funds for acquisitions. Donations of material were sought from exhibitors at the Sydney Exhibition and also from the Melbourne Centennial International Exhibition, held in 1880. The Committee reported to the Trust that "the Premier



expressed himself of the great utility and importance of the institution”.

The new branch of the Australian Museum was closely modelled on five London museums—the South Kensington Museum, the Bethnal Green Museum, the Museum of Practical Geology, the Patent Office Museum, and the Parkes Museum of Hygiene. Its collections fell into categories similar to those which had been shown at the International Exhibition, categories which are difficult for us to appreciate now. The Technological Museum had a strong economic bias which nowadays is pursued elsewhere; major early collections were in economic zoology—“two dressed sides of porpoise leather, blackened and waxed on both sides, suitable for boot laces”; economic geology—“bat guano”, economic entomology—“Queen Travelling Cage. For sending queen bees through the post”, economic botany—“Black Wattle Gum. *Acacia*

to the products of New South Wales and Australia generally”.

In 1881, the Australian Museum Trust received permission from the Department of Public Instruction to use the Exhibition Building, and voted £100 to provide for the cataloguing and arrangement of the ethnology collections in the Garden Palace, in a gallery appended to the technological collections. In the same year J.H. Maiden was appointed as the first curator of the new museum. On June 6 the Trust agreed to transfer all ethnological collections from the main Museum building in College Street, to the Garden Palace for exhibition and storage.

On the night of September 22, 1882, only two months before the Museum was expected to open to the public, the Garden Palace and most of its contents were destroyed by fire. Damage sustained by the Technological Museum was estimated at nearly £11,000.

One segment of the Shoalhaven River Bridge on display in the Exhibition grounds.



*decurrens*. Sold in Sydney as ‘Chewing Gum’, educational appliances—“A collection of school books”, wool; applied art; ethnology; metallurgy and machinery, and sanitary appliances—“in the belief that a well-arranged collection of sanitary appliances will prove of very material benefit to the country”.

The Government set aside ‘over 30,000 feet’ (sic) in the south western portion of the Garden Palace for the new Museum. The additional needs of the Museum seem minimal by today’s standards: in addition to the existing display space, the museum was to have a library, reading room, chemical laboratory, and work-room. The laboratory was included “for the prosecution of original chemical and physical research, with especial reference

In true Public Service tradition the events of the early 1880s were recorded not in order of importance but in chronological order in the Committee’s Annual Reports.

Subsequently the few technological exhibits that had been saved from the fire were moved into the Agricultural Hall remaining from the 1879 Exhibition and the Committee once again set about building up collections. Ethnology, however, was returned to the main Museum building in College Street and the two collections were never again associated.

Within a few years, this home of the Technological, Industrial and Sanitary Museum was itself declared insanitary. Showcases stood one upon the other, and the number of visitors was falling off considerably. On



several occasions during the 1880s the Ethnological Committee expressed its concern over the state of the Agricultural Hall and the collections housed in it. On September 3, 1889 the entire committee resigned and on December 31 The Australian Museum Trust relinquished all responsibility for the technological collections.

On New Year's Day 1890 the Department of Public Instruction assumed control. Thus the connection between The Australian Museum and the Technological collections was finally severed.

Two years later work began on a new building in Harris Street, Ultimo, designed by William Kemp, and in 1894 the Technological Museum was opened. It is interesting to see the resemblance in plan between Kemp's building and the Garden Palace.

In spite of the fire, some items from the 1879 Exhibition survive to this day in the Museum of Applied Arts and Sciences, successor of the Technological Museum. A graphite elephant is said—somewhat improbably—to have passed nearly unscathed through the fire. Other items from the Exhibition were acquired later from subsequent owners: a triple expansion marine engine installed in the ferry 'Pheasant', Japanese ceramics transferred from the Art Gallery, and a few others. The Geological and Mining Museum has some fossils collected by the Rev. W.B. Clarke, which passed through the fire and show the effects, while the Art Gallery has some of the pictures. The most substantial reminder of the Exhibition must be the iron bridge over the Shoalhaven River at Nowra, one of the eight segments of which was shown in the Exhibition grounds.

Similarly, although all of the ethnological collections in the Garden Palace were destroyed, some of the Australian Museum's pre-1882 material survives. This consists of artifacts which were exchanged with private collectors and with other public institutions prior to the fire. The specimens which went to private collectors may be as ir retrievable as those destroyed by the fire; however those still in public institutions may yet be brought to light.

Archival research by the Australian Museum has traced one of these collections assumed to have been destroyed in the Garden Palace. Just before the fire the Australian Museum was negotiating an exchange with the South Australian Institute, later to become the South Australian Museum. In the weeks following the fire neither the curator in Sydney nor his counterpart in Adelaide knew whether the transfer had been completed and so a new consignment was despatched. The transfer however, had been carried out and the original consignment not identified. Recent investigations among this material in the South Australian Museum have identified several mid-nineteenth century specimens from New Ireland, PNG and several from the north Solomon Islands.

Prior to the burning of the Garden Palace the ethnological and technological collections had been brought together to form the new museum in the Exhibition building. The fire severed the areal connection between the collections and the Australian Museum soon developed new directions in its approach to its material culture collections. The Trust requested the Colonial Government to allocate extra funds to replace material lost in the fire. During the first years after the fire the Museum purchas-



ed several major collections from the Pacific Islands. One of the most significant is the Mason brothers' collection, which comprised two thousand well-documented ethnological specimens and one thousand ornithological specimens.

The Inter-Colonial Exhibition of 1872, a forerunner to the Sydney International Exhibition.

The Pacific and Australian artifacts destroyed in the fire were for the most part collected during the early contact period, in areas which even by the 1880s had been extensively acculturated—areas such as the Clarence River in northern New South Wales and the Torres Strait Islands.

The Ethnological Court of the Garden Palace Exhibition brought together a wealth of nineteenth century Pacific and Australian artifacts; it was also the site of the destruction of that same material. During the closing years of the nineteenth century the Trustees of the Australian Museum attempted to replace the burnt material culture collections. However, a culture constitutes a unique event in time and space—it is never possible to replace destroyed cultures.

'Under the central dome' became a popular meeting spot. The bronze statue of Queen Victoria can be seen in the background.





# IN REVIEW

INTERNATIONAL TRADE IN WILDLIFE by Tim Inskipp and Sue Wells. *Earthscan 10 Percy Street, London W1P ODR, 1979. Price £2.00 sterling*

The Convention on International Trade in Endangered Species of Wild Fauna and Flora, commonly known as the Washington Convention or CITIES, was signed in Washington DC in March 1973, and entered into force in July 1975. Fifty-one nations were members of CITIES by March 1979, although there are still some notable exceptions, including Japan, Belgium, and the Netherlands.

The exact objective of CITIES is somewhat controversial amongst the member nations. Some see it as regulating the trade in wildlife so that a regular, sustainable wildlife crop can be taken; whilst others believe that the 'convention' should work towards the total abolition of international trade in wildlife.

*International Trade in Wildlife* by Tim Inskipp and Sue Wells and published by Earthscan London 1979, was originally produced as a briefing document for journalists on the international wildlife and wildlife-product trade, with special emphasis on CITIES.

The book begins with a history of national and international legislation and conventions concerning the wildlife trade. Perhaps the earliest wildlife regulations were instituted by the Incas in Peru from 13th-16th century in which the vicuna was considered sacred and killing one without permission constituted a state offence. By this means a valuable resource was carefully husbanded as a source of meat, wool, and skins. With the fall of the Inca Empire after the Spanish Conquest, this management plan was abandoned, and vicunas were killed indiscriminately. The vicuna is now one of the 642 animal and plant species in Appendix I of CITIES; these are species threatened with extinction. The 262 listed in Appendix II are species not yet threatened but which could become endangered if trade is not controlled; while Appendix III lists 78 species which individual nations protect at home.

The authors point out that international trade in wildlife centres primarily on its products: fur, feathers, hides and meat, although live animals have been increasingly exploited.

Member nations of CITIES are listed together with their attendances at conferences or meetings. The articles of the convention are then discussed and their strengths and weaknesses emphasised, followed by a discussion of the convention's organisation.

'How is CITIES enforced — and how evaded?' — Chapter 4, provides an interesting insight into the ingenuity of people involved in the trade, and the apathy of some government officials.

'The Wildlife Trade' — Chapter 5, occupies almost 50% of the book. In this chapter the authors discuss the trade in the various types of animals and their products.

Many facts, either fascinating or horrifying are related; for example there is now a market amongst tourists in Africa for mountain gorilla skulls and 16 of the 250

animals remaining have been slaughtered by poachers since 1976 for this purpose; between 1969 and 1976, 11,500 rhinoceros horns were exported from Kenya; apparently kangaroo leather has more strength for its weight than any other leather.

Zoos and museums are criticised to some extent as they are nett predators on wildlife, despite the fact that many zoos are now attempting to breed their own replacement animals. The educational and research value of these institutions to the conservation of wild animals is apparently not considered to be significant by the authors.

One anomaly of the convention, not mentioned by the authors, is in the fact that all species of felidae are covered by Appendix II. This of course, includes the feral cat in Australia, which is an important predator on many of our native wildlife species.

Chapter 6 outlines the most recent CITIES conference in Costa Rica, March 1979, and the book concludes with annexes which give the full text of the convention and its appendices plus a bibliography.

Scattered throughout the book are illustrations consisting of photographs, and line drawings by Peter Scott, of some of the endangered species. The drawing of a pair of Grevy's zebra on page 11 is particularly excellent.

This book should be read by all people interested in wildlife. It will certainly create concern.—E.P. Finnie, *General Curator Taronga Zoo.*

A NEW GUIDE TO THE BIRDS OF TAIWAN, by Severinghaus and Blackshaw, *MEI YA publications Inc. US \$6.95*

This slim guide with Chinese text alongside the English text is a new and enlarged edition of the original publication *A Guide to the Birds of Taiwan*. There are 201 species covered in the *New Guide* and 43 species are depicted in colour. Information is given on status distribution, habitat, songs and calls, and behaviour.

A short note is given on how to use the guide and pointing out that distance and lighting can distort the size and colour of a bird thus sometimes making identification difficult.

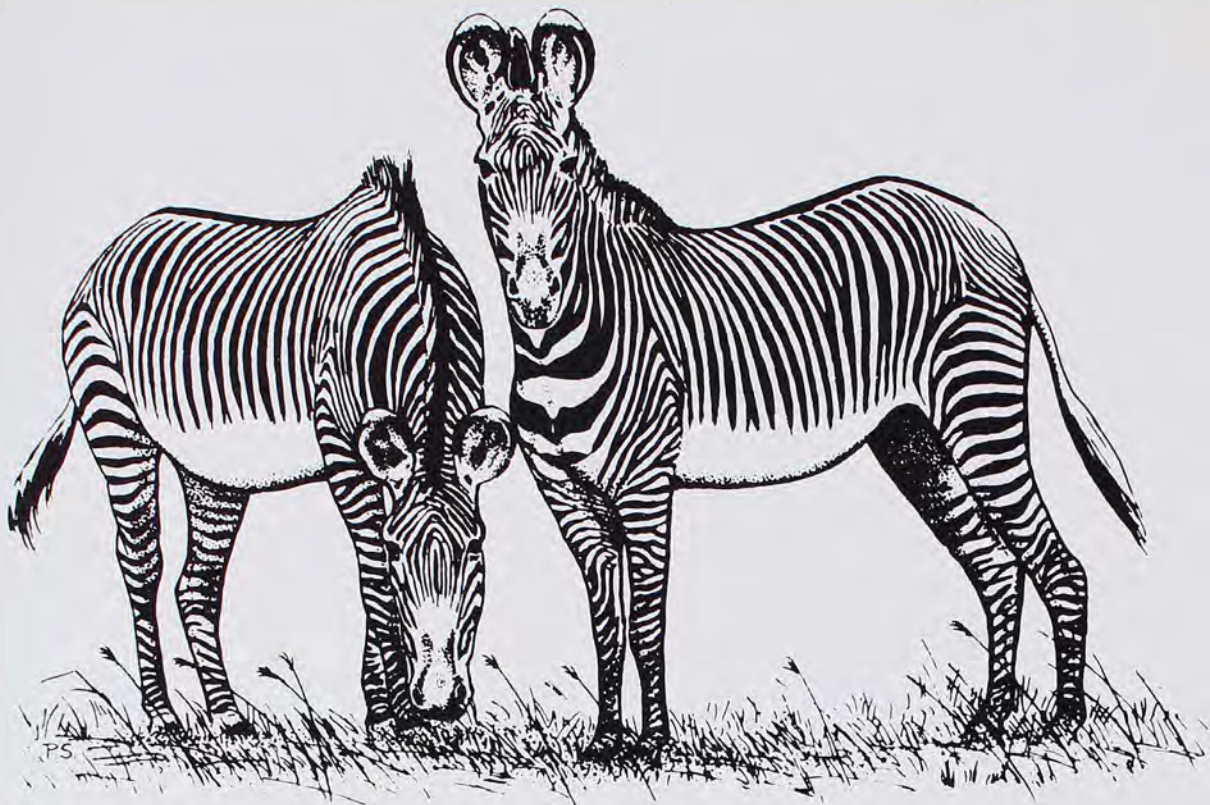
Naturally there are some errors, Plate I shows the Ruddy Crake with a green back instead of an olive brown back.

One or two technical words have crept in, which the ordinary bird watchers may not know such as 'endemic,' meaning only found in that country, and 'nuchal', meaning of the nape.

The coloured plates are simple and adequate for the price being paid for the book.

It is felt this book should help both visitors and the Chinese to get a better understanding of the birds of Taiwan.—H.J. de S. Disney.





Grevy's zebra was placed on CITES Appendix I in 1979, after uncontrolled hunting had greatly reduced its numbers in Kenya. From *International Trade in Wildlife* by Tim Inskipp and Sue Wells. (Drawing: Peter Scott, Fauna Preservation Society).

#### ERRATA: July-September 1979

The table of measures published on page 350 of the Special Energy issue was incorrect. Our apologies to readers and authors—correct measures are:

#### TABLE OF MEASURES USED THROUGHOUT THE ENERGY ISSUE

WATT (W)—unit of power  
 KILOWATT (kW)—one thousand watts  
 MEGAWATT (MW)—one million watts  
 JOULE (J)—unit of energy; to lift the weight of a one-kilogramme mass a distance of one metre requires approximately ten joules  
 CALORIE (cal<sub>17</sub>)—4.19 J approximately  
 MEGAJOULE (MJ)—one million joules

MOLE (mol)—amount of substance; equal in grammes to its molecular weight, eg: 1 mol H<sub>2</sub>O = 18g  
 GRAMME (g)—sub-unit of mass, one thousandth of one kilogramme  
 KILOGRAMME (kg)—unit of mass, 2.2lb approximately  
 10<sup>6</sup>—one million  
 10<sup>9</sup>—one thousand million  
 10<sup>21</sup>—one thousand million million million



