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THE ARCHIVES

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AUSTRALIA

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HARVESTING

PIG-NOSED
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WINTER 1987 VOL. 22 NO.5

THE AUSTRALIAN MUSEUM



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Front Cover

The Dingy Swallowtail, *Papilio anactus*. This painting, by Helena Scott, complete with foxing spots and correction marks, is from the library archives of the Australian Museum.

EDITORIAL Discoveries Diverse

Discovery. The word usually refers to finding something new. In this issue we adopt a different slant by looking back to discover something old—some of the magnificent 19th century illustrations by Harriet and Helena Scott (p. 194). These two sisters worked as scientific illustrators and their paintings have been cloistered in the library archives of the Australian Museum for well over a century. Also looking back at Australia's past, Gordon Grigg salutes the camel: the capabilities and endurance of this large, arid-adapted species contributed enormous-

ly to the early exploration of this country (p. 220). But discoveries are not always 'large'. Small things are easily overlooked. The stunning close-up photographs of bryophytes—miniatures of the plant world (p. 238)—will ensure that your eyes are kept well to the ground when next out in the bush. Discover also in this issue what it is like to live at the base of an active volcano in the Solomon Islands. Find out how this affects the people who live there (p. 210) and if Australia really *is* volcanically dead. You might be surprised!

—Fiona Doig, Editor



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Painted by
Harriet Ann Morgan

Chelepteryx Collesi. G. Gray.

Engraved

The Scott Sisters

Art treasures of the 19th century revealed

By Marion Ord

“Oh! you cannot think how thankful I am that my dear father allows me to place my name to the drawings! It makes me feel twice as much pleasure while I paint them!”

Helena Scott was 30 when she wrote those words to her childhood friend Edward Pierson Ramsay, who later became Curator of the Australian Museum. It was 1862 and she and her elder sister, Harriet, were already well launched on their careers as professional artists and natural science collectors and illustrators. They were acquainted through their father with scientists around the world, and with many in the colony of New South Wales. These included the Macleays; Dr George Bennett, who was the first Secretary, and Gerard Krefft, an early Curator, of the Australian Museum.

Harriet and Helena were the daughters of Alexander Walker Scott of Ash Island at Hexham, on the Hunter River. Walker Scott, “entomologist and entrepreneur”, was one of a large and influential family who had migrated to New South Wales from England in the 1820s. He was born in India, on the reclaimed island of Salsette north of

Bombay, “a naturalist’s paradise” not unlike Ash Island. His father, Dr Helenus Scott, was botanist and physician to the East India Company for almost 30 years and Walker inherited his father’s interests. As well as his botanical studies, however, Walker took his MA at Cambridge, studied law briefly, pioneered several industries and institutions in Newcastle, and was a Liberal member of the first Legislative Assembly for Northumberland and Hunter in 1856. He was also a trustee of the Australian Museum in 1864–66 and 1867–79.

“I’ve entered into a very stimulating association with a Mr. Robert Scott and his brother, Walker Scott”, wrote Ludwig Leichhardt in June 1842, soon after his arrival in Australia. “Their sister is married to a doctor named Mitchell [Dr James Mitchell of the Rum



Helena Scott

ILLUSTRATION PHOTOS BY JOHN FIELDS



Australian Lepidoptera

Hospital]. These people have been interested in natural history since their childhood and have been keen collectors of everything that seemed worthy of remark. I have certainly found their collection of minerals and shells instructive in the extreme."

Leichhardt visited Ash Island later in the same year:

"Mr. Scott has very kindly come with me on some of my tramps. He . . . is inclined to proceed briskly, like a nimble huntsman, and his sharp eyes notice the less conspicuous of the new varieties of plants more easily than mine do. . . It's a romantic place which I like well enough to think that—perhaps—I'd be content to live and die there."

In 1846 Walker Scott married Harriet Calcott, daughter of a convict "freed by servitude", with whom he had been living. She was the mother of his daughters Harriet and Helena, then 16 and 14. After the marriage he took them all to live on Ash Island, a grant of 2,560 acres which he had been developing since 1829. Ash Island oranges were famous in the colony and Scott experimented with flax and tobacco crops and grew grapes for wine. In 1847 he imported five German vine dressers to work for him.

To Harriet and Helena, who had been born in Harrington Street in Sydney's Rocks area, Ash Island introduced a freedom in which they could develop and indulge their talents, at their own pace. Already their father had taught them his skills in observation and exact



representation from life. Scott was a talented artist and his closest friend in England was the painter Edwin Landseer, whose portrait of Alexander Walker Scott resides in the Art Gallery of New South Wales.

From early childhood the sisters had visited the family of Dr David Ramsay of "Dobroyd" at Ashfield, another Scottish emigrant obsessed with natural science and new plant species. His wife, Sarah, was the daughter of emancipist Simeon Lord. The mix of scientists and emancipists formed a more liberal-minded community than that of the exclusives in the colony, who wanted to live like the English gentry and hated convicts, emancipists, the Catholics and the Irish. The friendship of the Scott sisters with E.P. Ramsay began at this time, continuing throughout their lives. Letters to him remain their only surviving correspondence. "You are one of the very few to whom I scribble just as I think so you may be sure I have confidence in you", wrote Helena ("Nellie") in 1862.

In the *Sydney Morning Herald* of 30 August 1851 appeared a long review of a work on moths and butterflies soon to be published: *Australian Lepidoptera and their Transformations, drawn from the Life by Harriet and Helena Scott, with Descriptions General and Systematic*, by A.W. Scott M.A. The review, by the eminent botanist W. Swainson on a visit from New Zealand

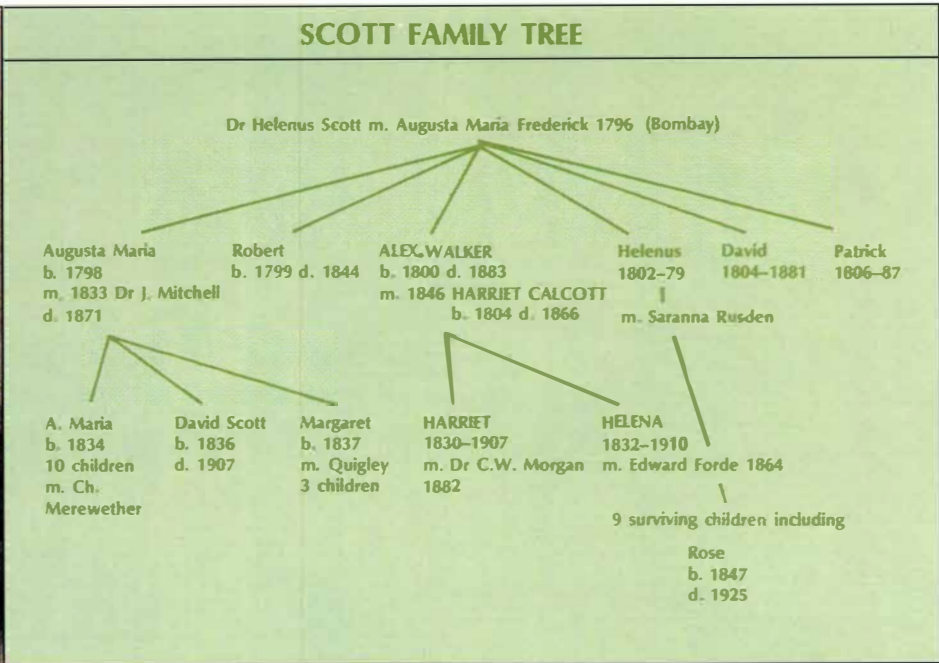
where he had emigrated, was premature. The Lepidoptera book, lacking funds, was not published in Australia but in England 12 years later, in 1864. Five hundred copies were then printed. Swainson noted:

"Of the execution of these drawings I am almost afraid to write lest the public may think that the desire of complimenting the fair artists . . . may have biased my judgment. I am willing, however, to hazard that scrupulous regard for veracity which the scientific public has long given me credit for, when I state that these drawings are equal to any I have ever seen by modern artists. . . Whether we look to the exquisite and elaborate finishing, the correct drawing, or the astonishing exactitude of the colours, often most brilliant, and generally indescribably blended, there is no poetic exaggeration in saying: 'The force of painting can no further go.'"

Swainson then discussed the Lepidoptera species under their different families, noting those not seen before and others which were important. "Commencing then with the diurnal or day-flying tribe, we have in Plate 52 the newly discovered *Amprisius Australis* [*Ornithoptera australis*, today known as *O. richmondia*] a large insect of surpassing beauty, recently discovered in the neighbourhood of the Richmond River. In its general colour it strongly resembles the famous Priam butterfly of Am-



Alexander Walker Scott



boyna and the Indian isles. . . That an insect of such dimensions and so strikingly beautiful should only just have been discovered, is but one of the many proofs how little is yet known of Australian entomology beyond a short distance from the capital."

Under Noctuidae, Swainson wrote: "The present series. . . contains one of the most beautiful species known, which seems to be the same. . . or closely allied to others found in India. It is the *Catocala Menispermi*, Plate 17 of our author, and is as richly coloured in its larvae as in its perfect state. This drawing is one of the most beautifully executed in the whole collection."

Many of the Lepidoptera were drawn against landscapes of Sydney in the style of Conrad Martens, a friend of the Scott family and best-known of the colony's painters. As a result of their work, the sisters were elected honorary members of the Entomological Society, a unique honour for women of their time.

Later in 1864 Helena Scott married an Anglo-Irish artist and navigator, Edward Forde, who was working for the Department of Harbours and River Navigation. They were married on Ash Island and a young cousin, Rose Scott, who was later to become famous as a social reformer, was one of the witnesses.

The couple moved to Sydney and in 1865 sailed for Adelaide. Dr Lionel Gilbert wrote: "Edward Forde was sent to survey the





Darling River between Wentworth and Bourke for obstructions to river navigation. Helena Forde accompanied her husband and by August 1865 she was collecting and painting specimens around the survey camp near Wentworth, a noteworthy effort for a woman in such a remote area at that time... By March 1866 she had a reasonable amount of material on hand for her proposed illustrated 'Flora of the Darling'. In the vicinity of Menindee, however, both husband and wife contracted fever. Helena recovered but Edward died on 20th June, 1866 'of low fever and exhaustion'."

On the return to Sydney, Helena gave her material to William Woolls for his work *A Contribution to the Flora of Australia* (Sydney, 1867). Gilbert wrote:

"Hers was probably the most representative collection of plants from the lower Darling brought to Sydney up to this time." Part of it later found its way into the collection of Von Mueller in Melbourne.

Meanwhile Harriet or "Hattie" lived on at Ash Island with her parents and half-sister Mary Ann. There were visits to Wollongong where she painted several landscapes, and to Sydney, and commissions for Ramsay and others. Harriet, who longed to have been "Harry Scott instead of Hattie Scott" and to have had a university education, was delighted and a little in awe of her own success:

"Fancy Mr. Krefft introducing Papa to a friend of his... a Mr. Pitt... and the said Mr. Pitt accosting Papa with 'Are you

the Mr. Scott that has the clever daughters?'"

But early in 1866 Mrs Scott died. Walker, Harriet and Mary Ann moved to Sydney. Walker, inept in business matters, was made bankrupt and the Ash Island property sold, although Scott's books and personal belongings were returned to him by his creditors. Harriet now gladly embraced the life of the city "where we can be much happier than at so very quiet a place."

For several years Harriet and Helena executed almost all the artwork for scientific literature produced in Sydney, including J.C. Cox's *Monograph of Australian Land Shells* (1868) and Krefft's *Snakes of Australia* (1869) and *Mammals of Australia* (1871). They also designed the first Australian Christmas cards, printed by Turner & Henderson in 1879.

In 1882 Harriet married Dr Cosby William Morgan, recently widowed, who was an old friend from the days at Newcastle. They lived for several years at Pambula on the south coast. Harriet did little work after her marriage although she illustrated the 1884 and 1886 editions of the *Railway Guide*.

After Walker Scott's death in 1883, Helena persuaded the Australian Museum to publish the second volume of his *Lepidoptera* in five parts (1890-98). As a freelance with no other capital, she had to earn her own living. "I must try and earn a little money somehow to keep the wolf from the door", she wrote to a cousin in 1904 when she was 72. She had applied to the Museum for "some scientific work which is all I am fit for...".

Harriet Scott died at Granville, Sydney in 1907 and Helena at Harris Park, a few streets away, in 1910. They were bypassed in history until Nancy Gray began to collate the Scott family papers in the Mitchell Library some years ago. Fortunately their extraordinary work survives to speak for them, and to recall the painstaking hours spent on Ash Island recording the life cycles of moths and butterflies. □

The *Ash Island Series*, the work of Harriet and Helena Scott, is scheduled for publication in 1988 by The Craftsman's Press. The books, arranged and introduced by Marion Ord, are: *Historical Drawings of Moths & Butterflies, Vol. 1. From the Collections of The Australian Museum*; and *Historical Drawings of Native Flowers, Vol. 2. From the Collections of The Mitchell Library*.



Male Palm Cockatoo.

PALM COCKATOOS:

Drumming to a different beat

By Graham Wood

Waking one morning to the usual wet season drone of countless insects and calling birds, a new sound registered in my mind. Was someone, something, playing tricks on me? In the distance was the unmistakable sound produced by the beating of something on a hollow log. By the time I reached the door of my humpy the drumming had ceased and my attention was drawn to the cackling whistle of a Palm Cockatoo (*Probosciger aterrimus*) passing overhead. Was it the drummer? It was certainly

J.M. LABAT, AUSCAPE



GRAHAM WOOD

Male Palm Cockatoo engaged in an early morning drumming performance using a *Grevillea glauca* seed capsule.



GRAHAM WOOD

Drumming implements used by Palm Cockatoos. The round objects are the seed capsules of the *Grevillea glauca* tree. These were used by bushmen as clothespegs.

worth further investigation!

So began a fascination with a truly remarkable bird. I had come to Iron Range, on north-eastern Cape York Peninsula, to familiarise myself with changes in the fauna, particularly the insects, brought about by the wet season. But the course of my studies was about to take a radical change in direction.

Several days later I woke to the same sound. Moving along the edge of the forest, guided by the drumming, I found myself peering up through a break in the canopy. Silhouetted against a sombre sky was a Palm Cockatoo, wings outstretched, turning from side to side and beating the top of the hollow trunk on which he was perched. The large bill and superior size suggested to me it was male. All too quickly he departed, leaving me with the puzzle of how such volume was produced. Certainly he could not just have been beating with his foot.

Several days passed until I witnessed the next, although brief, performance. The other member of the pair, which was standing sentry, raised the alarm and they were gone. But, on departing, the performer dropped the piece of branch he had been using as a drumstick. This bounced noisily down the interior of the stump, unfortunately beyond my retrieval.

Being now familiar with this haunt, I was determined to observe the whole performance. Reward came quickly, with the arrival of the pair before dawn one morning. Following several minutes of preening, the male flew to a nearby tree. Clamping his beak around a two-centimetre-thick branch, he rocked back and forth in pipe-cutter fashion. A 'snap' heralded success, a second 'snap' and the foliage end was gone, leaving a length of about ten centimetres. Flying to the top of the display trunk he spent several minutes chewing the branch, removing pieces of bark. He then beat the hollow trunk loudly with the stick, which he held in his foot. This time I was able to retrieve the drumstick.

The drumstick produced by the Palm Cockatoo is certainly the most complex tool used by any bird and arguably the most complex used by any animals other than humans. Only the tools used by primates rival it in complexity. Few of the devices used by other animals are actually produced and modified, as the drumstick is. The drumstick is also the only tool produced by a non-human animal that is not used in procuring food and, to my knowledge, the only musical imple-



Pair of Palm Cockatoos at the entrance to a nest hollow. The male is in front, distinguished by his larger size and bigger bill. Both birds are panting and holding their wings away from their bodies in response to the heat of mid-morning.

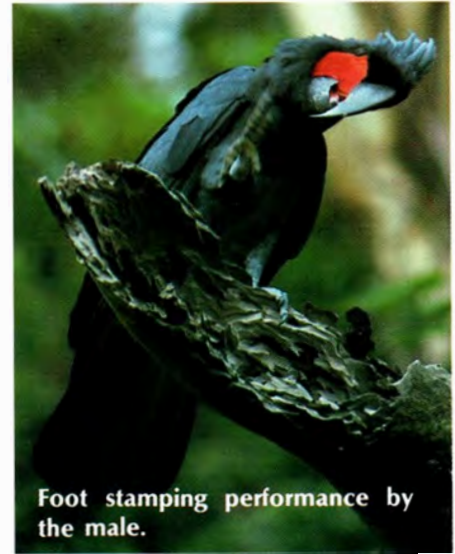
GRAHAM WOOD

ment produced by any animals other than humans. Its purpose is to acoustically delineate territory and probably has a pair-bonding function.

Months passed without the hint of a performance. As the 'dry' season progressed I moved toward the coast, setting up camp in open woodland—main habitat of the Palm Cockatoo. Here I identified many potential display sites, which invariably focused on a tree hollow with possible use in nesting. To avoid disturbing their performances I built hides at selected sites. From these I was able to observe closely their musical performances.

Each pair of Palm Cockatoos had a number of hollows that were regularly visited at the beginning and close of each day. A morning visit usually commenced with preening, followed by an examination of the hollow and the occasional drumming performance. In this open country the drumming implement, rather than being a stick, was usually the nut of the *Grevillea glauca* tree, the so-called 'Bushman's Clothespeg'.

Drumming performances were most intense during nest preparation and just prior to the single young (only one egg is laid) leaving the nest. With



Foot stamping performance by the male.

GRAHAM WOOD

the urge to nest came the lining of a number of hollows with a bed of shredded sticks. At this time the hollows were most jealously guarded. There was considerable competition for suitable nest hollows and disputes arose when a rival pair approached too close. The encroaching male was chased by the resident male and attacked whenever he landed. The resident flew directly at the intruder, lunging feet first and throwing his wings back prior to impact. The victim was usually knocked off his perch by the blow but, on the occasions that he managed to hold on, his attacker flapped wildly in a persistent effort to drag him off the branch. This attack was repeated until the encroaching pair departed. Beaks were never used in these conflicts—a sensible restraint when one considers their power. During the attacks the resident females flew beside their partners, screeching raucously but never making physical contact.

Following the departure of the encroaching pair the male prepared a drumstick and provided one of the best renditions I have witnessed. During this performance the female perched nearby, in silence.

During the last days before the young bird left the nest many drumming displays were performed. On a number of occasions both parents drummed at the same time. As if on cue the young bird, a male, left the nest hollow during one of these performances and flew to a nearby branch. Immediately he was attacked and knocked off his perch by his father. Although visibly shaken by this experience, he followed his parents, who departed immediately after the attack. This established his position in life until the next nesting season, still following his parents but keeping a respectful distance. □

Ground Orchids—Salute to Saloop

Ground orchids are enchanting plants. Each spring they brighten the forest floor with dainty blooms of the oddest colours and shapes. Enjoy them while you can, for they flower but fleetingly; each summer the leaves, stems and flowers die away.

My fascination with ground orchids blossomed last spring, during a long-term study of the traditional foods of Aborigines. Most ground orchids produce 'tubers' and early colonial writers listed these as Aboriginal foods. For years I paid them no heed, for I encountered ground orchids infrequently and the tubers I dug up were tiny. But then I came upon an intriguing article on Aboriginal diet by Melbourne botanist Beth Gott. She wrote:

"Accustomed as we are to the total protection of orchids in most states of Australia, we tend to dismiss the Orchidaceae [orchid family] as an important food source, considering them to be rare; yet orchids are widespread, even in quite dry areas, and are often locally abundant. They were widely exploited as a food source."

Beth wrote of finding Nodding Greenhoods (*Pterostylis nutans*) at the extraordinary density of 440 plants per square metre, yielding 800 tiny tubers, although with a combined weight of only 126 grams. Orchid tubers are easy to dig and, at densities like this, could serve as important foods.

I began to look out for orchids, and last spring reaped a bountiful reward. It began on a small knoll in southern Australia where I chanced upon four orchid species flowering side by side. The first, a Common Waxlip (*Glossodia major*), sported a single egg-shaped tuber with a pointed tip. This tuber tasted watery and slightly sweet, with a bitter aftertaste. It was not nice. The second, a Leopard Orchid (*Diuris maculata*), had two bullet-shaped tubers three centimetres long and six to seven millimetres wide, with a glutinous sticky taste. The arrowroot-like starch, although filling, stuck cloyingly to my gums. The third orchid, a Tall Greenhood (*Pterostylis longifolia*), had a pair

of globular tubers, 12 millimetres broad, with a watery bitter taste. The fourth orchid, Pink Fingers (*Caladenia carnea*) had two pea-sized white tubers, tasting sweet and juicy.

I was intrigued by this hilltop orchid entree. The tubers of these four plants were as varied in flavour and form as were the flowers in colour and shape. Although some of the tubers were not appealing, together they afforded a most interesting wild food snack.

Since then I have sampled the tubers of 12 genera and more than 20 species of ground orchid. Some were quite unpalatable although all were obviously edible, and a few were exceptionally tasty—especially the walnut-sized 'potatoes' of Brown Beaks (*Lyperanthus suaveolens*) and the fragrantly flavoured starch of the Horned Orchid (*Orthoceras strictum*). Most filling were the glutinous tubers of donkey orchids (*Diuris* spp.) and sun orchids (*Thelymitra* spp.) and I have no doubt that these were important Aboriginal foods.

Although most of the tubers were tiny, those of the common Hyacinth Orchid (*Dipodium punctatum*) were big. One plant had six long tubers, each between seven and eight millimetres thick and longer than my fingers. The tubers were watery and, for an orchid, unusually fibrous although less so after

cooking. These 'tubers' are actually large fleshy roots, which accounts for their fibrous texture. These were the only orchids that required cooking to improve the taste; the others I was able to eat raw.

Incidentally, Hyacinth Orchids are mysterious plants. Lacking leaves, they grow only beneath certain kinds of eucalypts and are said to be parasitic on a fungus. They seem to have the largest tubers of any ground orchid, apart from those of Cinnamon Bells, also called Potato Orchid (*Gastrodia sesamoides*), another leafless saprophyte, once eaten by Aborigines in Tasmania.

Hyacinth Orchids flower through summer but most orchids bloom in spring, which is when the leaves appear. Ground orchids are not very leafy plants, and many produce only a single leaf, others two or three. These soft, succulent leaves cannot withstand the scorching summer sun, and the plants 'gestate' through summer in the form of those starch-filled tubers, so important as foods.

Tuber-producing is a common tactic of small plants with soft leaves growing in a harsh climate with seasonally dry soil. Besides orchids, many of the smaller lilies and the Murnong or Yam Daisy (*Microseris scapigera*) depend on tubers. These plants often grow together in shallow soils and Aborigines no doubt harvested them in large numbers.

The tiny tubers could have served as staple foods in spring, when these



The dark-flowered form of the Hyacinth Orchid flourishes in a patch of bushland in Brisbane's western suburbs, close to a main highway. The roots measure up to 13 centimetres in length.

plants are in flower, but I was curious to know if Aborigines would have harvested them in other seasons, when the plants are less obvious.

At first it seemed unlikely. Last October, in the granite mountains near Stanthorpe, I found colonies of Brown Beaks within which only half the plants were flowering. This orchid has a single leaf remarkably similar to Blady Grass (*Imperata cylindrica*), and both plants often grow together so that the orchid is extremely difficult to locate without its flowers. On open ground the leaf is noticeable but still easily overlooked. Could Aborigines have gathered an orchid like this outside the flowering season?

Last summer I stumbled upon the answer. I was photographing Hyacinth Orchids in disturbed bush in suburban Brisbane where, surprisingly, this orchid is locally common. Many of the orchids were past flowering, and I took note of their distinctive oval capsules. Two weeks later, in South Australia, I was tramping through the hills behind Adelaide when I spotted a similar egg-shaped capsule on a dried stalk. Could this be an orchid? I clawed into the dirt and, to my astonishment, unearthed a shiny white tuber shaped like a grape. This came from no Hyacinth Orchid but was obviously of orchid origin. Its crisp white starch tasted sublime. Excitedly I



The flower of the Spider Orchid (*Caladenia dilatata* X *patersonii*) is too spectacular to justify the harvest of its tubers, which are tiny and watery.



The tubers of Brown Beaks resemble small waxy potatoes, and have a juicy and fragrant flavour. The flowers are shown at left.

scanned the nearby forest and realised there were dozens of these dried pods, all signalling tiny stores of food hidden in the hot earth. These tubers were so common that a forager could have lived happily off the land. The different shapes and tastes of the tubers confirmed that several orchid species were present.

Elsewhere in south-eastern Australia it was the same. In southern Victoria, in coastal New South Wales, wherever I looked I found tubers—sometimes by spotting a dainty flower but more often by finding dried capsules in the wiry grass. Occasionally I made a mistake, confusing the capsules of trigger plants (*Stylidium* spp.) with orchids. But there could be no mistaking the significance of my find—that, for the Aborigines, orchids were a source of sustenance all year round.

Ground orchids are no longer on my menu. I cannot justify the continued harvest of these beautiful plants. Nor would I want others to follow my example. Orchids are protected in some States, and rightly so. There is, however, an interesting appendix to my tale. During my reading on orchids I came upon several old references to white people eating the tubers, both here and overseas.

Consider the following comment by colonial Australian botanist Joseph Maiden, writing in 1898:

“There is hardly a country boy who has not eaten so-called Yams, which are the tubers of numerous kinds of terrestrial or ground-growing orchids.”

Even more surprising is Anne Pratt’s description of ‘salep’ (orchid starch, also called saloop) in her 1891 book *Flowering Plants, Grasses, Sedges and Ferns, of Great Britain*:

“Salep is little used now in this country; but less than a century since, the Saloop-house was much frequented, and the substance was a favourite repast of porters, coal-heavers, and other hard-working men. It is said to contain more nutritious matter, in proportion to its bulk, than any other known root, and an ounce of salep was considered to afford support to a man for a day; hence those who travel in uninhabited countries have greatly prized so portable a vegetable food.” □

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KATHIE ATKINSON

Red Kangaroo, *Macropus rufus*.

KANGAROO HARVESTING: A new approach

By Gordon Grigg, School of Zoology, University of Sydney

What can be done to repair the habitat damage done by 100 years of overgrazing? A solution in the marginal pastoral areas may be to promote kangaroo products, increasing their value so that it becomes more profitable to harvest kangaroos there instead of sheep and cattle.

Consider what would happen if the value of kangaroos suddenly jumped three- or four-fold. Many people would immediately think that this is the worst thing that could happen; that the large species of kangaroos would come under such harvesting pressure that extinction would surely follow. I disagree. I believe that a big increase in demand for kangaroo products would not only ensure their conservation but would lead also to the rehabilitation of areas now becoming deserts under the pressure of hard-hoofed stock. This Forum article will argue that, with conservation motives, we should be finding better

overseas markets for kangaroo meat and hides, and selling them at prices that do justice to their quality, instead of at prices that reflect their current status in Australia as pests.

You think I'm crazy? Hear me out, point by point.

Flying low over most of Australia, as I have been doing regularly for more than ten years on kangaroo surveys, I am always appalled by the extent of habitat damage I see inflicted by sheep and cattle grazing. The land is criss-crossed by tracks and beaten to powder. Much of our marginal grazing land is already well on the way to becoming desert. Just try to imagine what the country will look like in another 50 years, let alone another 200.

Or do you think we know better now; that the lessons of the past have been learned well and that pastures are better managed nowadays? Well think again! The latest trend in clapped-out

pastoral country in central New South Wales is to electrify existing fences so as to raise goats, which eat *everything!* Look at northern Africa!

Something must be done.

The best hope for restoration and conservation of our fragile arid lands is for the removal of sheep and cattle—not just to reduce grazing pressure, but to reduce foot pressure as well. Kinchega National Park, a formerly overgrazed sheep property south-east of Broken Hill, provides a practical example that many will be familiar with. However, for stock to be removed, there needs to be an alternate economic base. If kangaroos can provide that alternate base, there will be a revolution in land use in many of the areas now only marginally useful for grazing and, wherever it happens, there will be habitat restoration on a grand scale.

Graziers raise sheep deliberately and kangaroos inadvertently on most sheep properties. They regard sheep as a source of income, kangaroos as pests. A property might have 6,000 sheep and 3,000 kangaroos. The grazer reaps a financial benefit from the former, but calls in a licensed kangaroo shooter to kill and sell the latter. This is a paradox. Its persistence is cultural (kangaroo work is, in many cases, beneath the dignity of most graziers) and financial (kangaroos are not worth enough at present).

But, if the value of kangaroos increases, then graziers might think twice before giving them away. There are isolated examples of this now, even at the present low-market value of kangaroos. During 1986, when sheep prices were low, many graziers in central Queensland harvested their kangaroos themselves. A dramatic price increase would see more graziers doing this and fewer graziers would be forced off their land in times of drought and increasing interest rates.

How much of a price rise would be necessary? This question was addressed by Michael Young and Allan Wilson of the CSIRO Division of Wildlife and Rangelands Research (personal communication). Even including the costs of constructing and maintaining kangaroo-proof fencing, which I consider to be counter-productive, they estimated that a three- to four-fold increase in the price

R U M

of kangaroo meat would make farming profitable, first as a supplement to and then as a replacement for traditional stock.

How could such a price rise be achieved? A basic principle of economics is that if supply remains constant and demand rises, then price also rises. The supply of kangaroos is limited by quotas set to ensure their conservation (as it should be), so we need only to increase the demand. At present, kangaroos are undervalued, their present price reflecting their status in Australia as pests instead of something very special on which, we should remember, we have a complete monopoly. The leather is excellent and is sought by manufacturers of many specialised products, particularly sport shoes and other sporting equipment. The meat, with less than one per cent fat compared to 40 per cent for mutton, is a nutritionist's dream. With better marketing, particularly in countries that have a protein shortage (such as Japan), where there is a tradition of eating game (such as Germany), or in any country with a 'health food' industry, prices will inevitably rise. Even the motivation for the harvest—that of reversing our grazing-induced desertification—could be a selling point in Australia and in all other conservation-conscious countries.

In brief, my scenario is that kangaroos should be marketed at higher prices, reflecting the special product they are. Graziers in marginal country will then see a benefit in encouraging kangaroo populations by reducing and, in some instances, replacing entirely their traditional hard-hoofed stock. This will result in a sounder economic base in many areas and will promote the restoration of land that is turning into desert under present land use.

You still think I'm crazy, don't you? I can imagine many of the criticisms: "just another academic in his ivory tower, flogging his hobby horse"; "doesn't know anything about the bush"; "everybody knows you can't farm kangaroos"; "you'll need a big fence to keep them in, mate"; "what about the worms?"; "the Greenies'll never let you do it, anyway"; "you can't muster them" and so on.

Well let's concentrate on some of

these old chestnuts. After all, the *status quo* is hardly anything to be proud of, and I'm sure I'm not the only one who sees a need for new directions.

First of all, I'm not suggesting conventional farming, but free-range harvest of a natural resource (something closer to fishing than to farming). Fences would not be needed. Indeed, fences would probably be deleterious because kangaroos need freedom of movement, particularly during droughts. So how would you establish ownership over your kangaroos? Why would you need to? *Your* kangaroos are the ones on *your* property. Next week they may be on your neighbour's but, if you look after your land better than he does (that is, by reducing or removing hard-hoofed stock), then they may stay on yours. Mustering? Not necessary. Shooting has already proved to be an effective

“. . . if the value of kangaroos increases, then graziers might think twice before giving them away.”

and humane method of harvest and doesn't require the process of mustering. Indeed, kangaroos could not be mustered because they are prone to post-capture myopathy, a stress-induced deterioration of the muscles that degrades the value of the meat. Worms, parasites, health aspects? In South Australia, the only State where kangaroo meat can now be sold for human consumption, it passes regular inspections with flying colours. Note also that overheads fall, there being no need to maintain fences, to brand, drench, crutch or spray.

And the Greenies? Well, I think this proposal will be supported by more conservation groups than will oppose it; after all, economically valuable species are those that *everyone* wants to conserve and habitat restoration becomes a bonus. If there is local support, support from overseas will likely follow for the same reasons. In my view, this is a proposal on which producers, governments and conservationists

should be able to work together.

In an article in this magazine in 1984 (vol. 21 no. 4, p. 123) I discussed the kangaroo question at length, including population data and ethics. The article concluded that Red and Grey Kangaroos were not threatened by controlled harvesting. This conclusion is accepted by most people nowadays. What that article said, essentially, was that there are no reasons *not* to harvest kangaroos; what this present article is saying is that there are good conservation reasons *to* harvest.

Of course, if this proposal is put into effect, there will have to be many changes in the structure of kangaroo marketing and stricter controls to ensure that the resource is managed properly. Regular monitoring of populations should continue, with effective and intelligent control over the numbers taken. There would need to be effective ways to be certain that only legally-taken skins (tattooing?) and meat enter trade markets, and there would have to be a much higher level of supervision than at present. This will be crucial, otherwise there will be extensive poaching by unlicensed shooters, with all its unsavoury aspects. Many opponents of the industry have claimed that there is considerable corruption and that rules and regulations are not policed. But, with a higher dollar value on the resource, adequate controls and higher penalties are much more likely to be implemented than they are at present. While the proposal is aimed mainly at the marginal grazing areas, I see no reason why the kangaroo industry should not continue in other areas, as it does now, but with better regulation. The greater value of kangaroos would lead to more energetic controls in these places too.

I am not so naive that I think this proposal is a cure-all for the problems in our arid lands, or for the problems surrounding the commercialisation of kangaroos. However, I am urging constructive discussion. I hope this article will start some. The spread of deserts is a problem in many countries. Perhaps in Australia we may be able to do something about it. If switching to kangaroos works effectively even in just a few areas, then that will be a good start. How far it might go, who can tell? □

BOOK REVIEWS

Boles on Birds, Recher on Wrens



Reader's Digest Complete Book of Australian Birds.

Richard Schodde and Sonia Tidemann. *Reader's Digest*, Sydney, 1986, 2nd ed., 639 pp. \$49.95

The Slater Field Guide to Australian Birds.

Peter, Pat and Raoul Slater. *Rigby Publishers*, Sydney, 1986, 1st ed., 344 pp. \$29.95.

The Birds of Australia. A Book of Identification—760 Birds in Colour.

Ken Simpson and Nicolas Day. *Lloyd O'Neil Pty Ltd*, Melbourne, 1986, 2nd ed., 352 pp. \$35.95.

The number of newly published books on Australian birds has proceeded at a substantial rate for several years and in the last few months of 1986 reached a rather high level. Among this outpouring were several notable volumes: two new editions of previously published books and one striking replacement for a standard Australian text. All were landmarks in Australian bird books when they first appeared, and continue to be so in their updated forms.

When it first came on the market ten years ago, the *Reader's Digest Complete Book of Australian Birds* made a major impact.

The format remains the same: each species, except

for the more irregular vagrants, are illustrated with one, sometimes more, high quality photographs from the National Photographic Index of Australian Wildlife (NPI-AW). This is accompanied by text of variable length, discussing various aspects of the birds' natural history; a short synopsis of the description, voice, nesting and distribution; and a range map. These accounts are supplemented by a short section depicting the variety of Australian habitats and a general section on bird biology and origins, particularly in the Australian context. The latter has been expanded and moved from the rear to the front of the book.

The size is too large for use anywhere except in the home, and the photographs, as beautiful as most are, have drawbacks for identification purposes. This, however, is not the function of the book; presentation of an attractive blend of quality photographic portraits and interesting text is. In this aim it succeeds admirably.

In the first edition, the species accounts were written by a number of authors who were acknowledged in the front of the volume and in the rear. The second edition, completely re-written by Richard Schodde and Sonia Tidemann, still has these authors' lists, creating the unfortunate impression that they are still responsible for comments that few would have seen or had any input in. The book frequently contains apparently new information on species' biology that has yet to appear in proper scientific format. While the first appearance of such information in a popularised book will not be

of concern to most people, it is a disturbing approach to the initial presentation of original information.

There has been a line of notable Australian field guides, including the famous *What Bird is That?* by Neville Cayley (first published in 1931 and many times since, including revisions) and the recent volumes *A Field Guide to Australian Birds* by Peter Slater (1970, 1974) and Graham Pizzey's *A Field Guide to the Birds of Australia* (1980). Each has had its strengths and weaknesses with none obviously superior overall. Now Peter Slater has collaborated with his wife and son to produce the best field guide to Australian birds to date.

Previous guides retained outdated formats in which plates, and often maps, were divorced from the text, forcing the observer to refer to several, often widely-separated pages for a single species. The major improvement of the Slater Guide is to conform to the well-established format used by a majority of the best overseas field guides: for each species the text and maps are on one page facing the relevant illustration. Other improvements are the size, which is smaller than Pizzey's (perhaps still slightly too large for easy back pocket transport) and the single volume, unlike the unwieldy two-volume arrangement of Slater's earlier work.

The plates are probably the best and most comprehensive (more young plumages included) of any of its immediate competitors (despite some occasionally distracting use of marbled background and subdividing the page), with the added plus of including the eggs of

each species on the appropriate plate. It does not have the detail of text found in Pizzey's book. In this respect it forgoes its usefulness as a more general reference for the specific purpose of field identification, yet permits the smaller size—a reasonable trade-off in my opinion. There are some rough edges such as the odd irregularity in the presence of range maps, and the aspects of plates mentioned above. There is also perhaps not enough contrast in the black and white plate of underwing patterns of birds of prey and ducks; at least one person who has used the book in the field has remarked on this point.

A cost-conserving urge may be implicated in some striking omissions in the Slater Guide. Surprisingly absent is a figure explaining the parts or topography of the bird used throughout the book in the text descriptions. Such a figure is a standard part of most guides, including Pizzey's and Slater's earlier guide. The single most astounding absence is the lack of an index to scientific names, an unbelievable solution to reducing the total number of pages. There is no illustration of the introduced Blackbird (rumour has it that this figure was at the rear of the book and disappeared in the company of the scientific names index). My suspicions are that these omissions were beyond the control of the authors who should be congratulated for giving us the state-of-the-art Australian field guide to birds.

The 'proper' format utilised in the Slater Guide did not first appear in that volume. In 1984, Ken Simpson and Nicolas Day

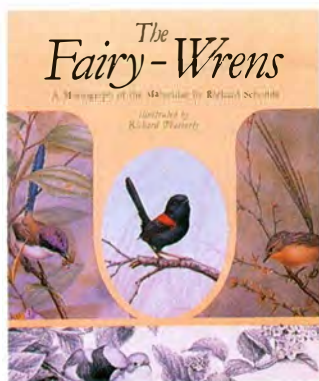
produced *The Birds of Australia* set out in this manner. It was also the first work to attempt to illustrate any sort of range of different plumages beyond the obvious adult ones. This section of the book is followed by "The Handbook", an extensive presentation (70 pages) starting with a brief introduction to the birds' biology, distribution, habitats and history in Australia and concluding with accounts of each Australian family of birds and their natural history. The format and quality of paintings by Day, which remain among the best in any Australian identification guide, ensured this book of a good reception. The second edition followed soon after, correcting some of the errors of the original and replacing some of the plates.

The field guide section holds its own in comparison with Slater but most observers will find it far too bulky to be a convenient field companion. "The Handbook" section will appeal to a number of people who are pressed to find this type of information in any other source. Combined, the two different styles of content make *The Birds of Australia* something between a field guide and a reference book.

Anyone having to decide between these three books and given only a single choice will need to consider the role it is intended to fulfill. If frequent field use is intended, there is no doubt that the Slater Guide is the obvious choice. Should there be little need of an identification guide but an interest in an attractive and informative book for reference with greater concentration on individual species' accounts,

the Reader's Digest book is the best selection. For the middle ground—the occasional foray into the bush as well as a general introduction to Australian birds—Simpson and Day's book suggests itself. If, however, one is not working under such constraints, one could do worse than to have all three of these worthwhile efforts in one's library.

—Walter Boles



The Fairy-wrens. A Monograph of the Maluridae.

Richard Schodde. Illustrated by Richard Weatherly. Originally published by Lansdowne Editions, Melbourne, 1982. Current distribution Connewarran Press, Mortlake, Victoria. 192 pp. \$70.

The fairy-wrens (Maluridae) are a group of 26 species restricted to Australia and New Guinea. Closely related to Australian warblers and honeyeaters, the fairy-wrens are part of Australia's own, home-grown avifauna. Because one species, the Superb Blue Wren (*Malurus cyaneus*), has made the adjustments to suburbia and city parks, fairy-wrens occupy a place in Australia's cultural natural history along with Kookaburras, wombats and gum-nut children. A book on

their biology is therefore an important event.

The Fairy-wrens was published in 1982; long enough to have been reviewed by others and discussed at length among ornithologists and keen bird-watchers. The review by Ian Rowley in 1985 (*Emu* 85: 271), doyen of malurid biologists, is certainly the most important and detailed statement yet to appear.

As presented by Rowley, there are two major criticisms of this book. The first and most important is that the author, Richard Schodde, has used it as a vehicle to publish ideas and observations without submitting them to the normal review processes that one expects for scientific writings. Thus unsubstantiated statements and errors of fact or interpretation may enter the literature and be accepted as correct by the less critical or those unfamiliar with fairy-wren biology. The second is that the artwork, albeit very nice, does not add significantly to the scientific content of the text. For a monograph, Rowley expects illustrations that show the different plumages of males and females, of young and old, of breeding and non-breeding birds or which document egg colour and shape, nests and various aspects of the birds' behaviour. To some extent Richard Weatherly's paintings and sketches do this but, overall, are basically irrelevant to the text and, Rowley suspects, have been used to sell the book.

Not being a malurid biologist, I have approached this book less critically than Rowley. Nor was I swayed by the labelling of the book as a monograph, which means

only that it deals more or less systematically with a single subject. Indeed, until now, I had ignored it as yet another of the 'coffee table' genre that plagues the world of natural history; I only opened it to prepare this review. This has been my loss as not only are the paintings superb, but the text is engagingly written and informative, and the historical accounts of the evolution of malurid taxonomy are akin to a good detective story. Unlike Rowley, who advises that you 'borrow' and not purchase *The Fairy-wrens*, I think a copy is money well spent. As Rowley states, "much of the text is ornithologically important" but it is also the most detailed (monographic) account of this special group of Australian birds available. Schodde has exhaustively reviewed the literature, bringing forth information that most of us would never realise existed let alone search for. If in places his observations are unsubstantiated or the text simplified, the risk that it will be misused is minimal. The author has made it clear where he is speculating on events and has made no pretence of having made any more than a good naturalist's observations and study of the birds. I say 'good on him'—that's what books are for.

The Fairy-wrens is not just a coffee table volume. I regret the format which makes reading difficult but it is probably necessary to show off Weatherly's paintings to advantage. I regret the absence of detailed plates of morphological and life cycle variation in plumage. But mostly, I regret not having read this book sooner.

—Harry Recher

The conservation status of Australian fishes has become a topical issue, mainly because of discussions among the fisheries scientists, administrators, students and fish enthusiasts who belong to the Australian Society for Fish Biology (ASFB). In 1980 a meeting of the ASFB recognised the need to provide an authoritative up-to-date classification of the conservation status of Australian fishes. The Society set up an Endangered Fish Subcommittee and circulated discussion papers among its members. When it became clear that a forum was needed to integrate the numerous and diverse pieces of information into the best possible classification of threatened fish, we sought the support of other interested bodies for a specialist conference. As a result, funds were contributed by the fisheries authorities of Victoria, South Australia, New South Wales and the Commonwealth. Contributions were also made by the Australian Freshwater Fishermen's Assembly, Native Fish Australia and ASFB.

The Threatened Fishes Conference

The Society's Conference on Australian Threatened Fishes was hosted by the Victorian Fisheries and Wildlife Division in Melbourne in August 1985. It brought together 52 people representing a broad range of expertise and made a detailed analysis of the status of Australia's fish fauna over two days. Dr Peter Maitland, Head of the Fish Group of the International Union for Conservation of Nature and Natural Resources, was invited from Edinburgh to be the conference's Guest Speaker. The conference designed a seven-stage scheme of classification for threatened fishes. Sixty-two species were listed. They included four 'endangered' fish: Trout Cod (*Maccullochella macquariensis*), Swan Galaxias (*Galaxias fontanus*), Eastern Freshwater Cod (*Maccullochella* n. sp.) and Clarence Galaxias (*Galaxias johnstoni*); four 'vulnerable' species: Flinders Ranges Gudgeon (*Mogurnda* n. sp.), Honey Blue-eye (*Pseudomugil melis*), Saddled Galaxias (*Galaxias tanycephalus*) and the Lake Eacham Rainbowfish (*Melanotaenia eachamensis*); five 'potentially threatened' species: the Australian Grayling (*Prototroctes maraena*), Elizabeth Springs Goby

(*Chlamydogobius* n. sp.), Swamp Galaxias (*Galaxias parvus*), Pedder Galaxias (*Galaxias pedderensis*) and the Non-parasitic Lamprey (*Mordacia praecox*); and the three lower classifications: 'indeterminate' (two species), 'restricted' (32 species) and 'uncertain status' (15+ species).

Causes of Fish Conservation Problems

The conference identified a variety of causes of fish conservation problems. Some were due to the highly localised distribution patterns of species, often in a single locality. Examples included the Lake Eacham Rainbowfish from northern Queensland, the Blind Cave Eel (*Ophisternon candidum*) from a small subterranean location on the central western Australian coast, and the Swan Galaxias from a single small Tasmanian stream.

Biological interactions such as predation and competition between species were often identified by the conference as causing the threatened status of various fishes. Examples of such interactions included the competitive effects on native fish of the introduced Topminnow (*Gambusia affinis*), otherwise known as the Mosquito Fish—an ill-deserved title since the small native fish it displaces probably provide better control of insect pests. Other examples include predation and competition by the introduced trout species (*Salmo* spp.) and Redfin (*Perca*

fluviatilis). Translocation of native fish between drainage systems was also seen as a threat. Although no species were listed by the conference as 'extinct', it has since been reported that the Lake Eacham Rainbowfish may have been exterminated by the translocation into Lake Eacham of another small native fish, the 'Mouth Almighty' (*Glossamia aprion*).

Fish often depend on the specific features of a particular habitat type. Many of the critical features of habitats are vulnerable to change. For example, the many catadromous species (those that breed in marine waters and whose young must migrate upstream) like Freshwater Herring (*Potamalosa richmondia*) or Australian Bass (*Macquaria novemaculeata*) are critically dependent on free passage through streams and so can be locally eradicated by impoundments. Other species depend on the availability of particular habitats for spawning, such as the sunken logs used by River Blackfish (*Gadopsis* sp.) or the gravel riffles used by Macquarie Perch (*Macquaria australasica*).

The degradation of habitat, especially through river regulation (dams, weirs, irrigation, etc.), stream siltation and catchment alteration, was recognised as the greatest factor leading to generalised declines in fish abundance and distribution. While such diffuse broad-scale forms of habitat degradation undoubtedly increase the vulnerability of many threatened species, only



The Trout Cod was listed as 'endangered' at the Australian Threatened Fishes Conference, Melbourne, August 1985.

GUNTHA SCHMIDA



The Lake Eacham Rainbowfish .

occasionally (for example, the Eastern Freshwater Cod or Swamp Galaxias) were they seen as the most immediate primary threat.

Excessive fishing pressure was reported as having threatened some species such as Tasmanian Whitebait (*Lovettia seali*) and Southern Bluefin Tuna (*Thunnus thynnus maccoyii*). Overfishing may also have contributed to the problems of other species, such as Macquarie Perch.

Lack of knowledge was identified by the conference as a further important cause of fish conservation problems. The low level of taxonomic knowledge of Australia's fishes is shown by the inclusion in the classification of 19 species that have not yet been formally described and named. Many large gaps were recognised in knowledge of the distribution of various fishes, and the ecology of most species remains poorly known. Such ignorance prevents adequate assessment of the status of fish and inhibits conservation measures.

The Future

Future work by ASFB on threatened fish will involve publication of the detailed *Proceedings of the Conference on Australian Threatened Fishes* (1987). An educational pamphlet illustrating some of the species and noting conservation problems will also be published. The Society has established an Endangered Fishes Habitat Subcommittee which will seek protection for the habitats of endangered and other classes of species. The southern Clarence River system habitats of the Eastern Freshwater Cod have already been nominated for the Australian Heritage Commission's Register of the National Estate. Research on various aspects of threatened fish will be promoted by the Society and the conservation listings will be regularly reviewed. □

—John H. Harris
Fisheries Research Institute

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Solomon's Volcanoes

Life on the Verge

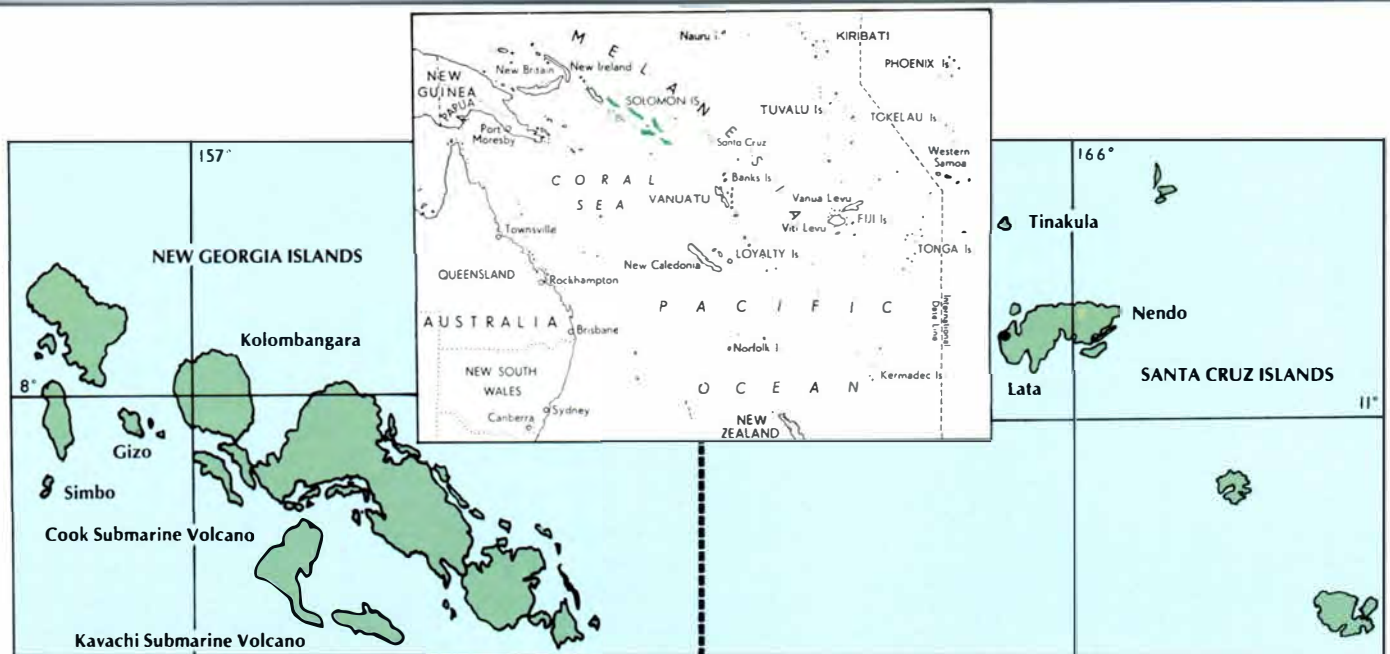
Text and Photos by
William Gladstone
School of Biological Sciences
University of Sydney

A murmurous rumbling was followed by a trembling thud; the time between the successively heavier thuds increased. A boulder from the smoking crater bounded down the solidified lava flow, clouds of ash marking its descent to the sea. It skimmed across the waves, hissing and steaming, red magma spraying from its molten heart. The boulder sank with a thunderous explosion. Tinakula, an active volcano in the eastern Solomon Islands, which last erupted in 1971, was restless.

Volcanic activity in the Solomon Islands shows that the Earth is far from stable. Seven major crustal plates and many minor plates float on a soft layer of the mantle, and these are moved about by convection currents. The outcome of two plates colliding depends on their relative speeds. Those that approach at less than five to six centimetres per year absorb the compression and buckle into mountain ranges. At faster impact speeds the forces cannot be absorbed and one plate slides under the other. Geologists believe the Solomon Islands arose when the leading edge of the Indo-Australian Plate, moving northwards, met and slid below the Pacific Plate, which is moving north-west. The overlying edge of the Pacific Plate was bent, creating a chain of islands and deep ocean trenches. As it slides into the Earth's mantle, the crust of the descend-



Ovi crater lake at the base of Simbo's volcano.



ing plate is converted into denser rocks and partly melted by frictional heat. The energy released from collision of the plates colliding generates earthquakes. The magma that develops during the bending of the plates rises and forms volcanoes at the surface.

The Solomon Islands stretch south-east from New Guinea to Vanuatu. Active and dormant volcanoes are dotted along the length of the island chain. All of the Solomon's volcanic islands are populated. How have the inhabitants' lives been shaped by the volcanoes? Are life forms now returning to areas that were devastated by previous eruptions? To answer these questions, I visited two volcanoes at opposite ends of the Solomons: Simbo and Tinakula.

Simbo

The western Solomon Islands have a diverse volcanic character. The active submarine volcanoes, Cook and Kavachi, regularly break through the sea surface, develop into small islands, and then collapse into the sea. Kolombangara is a large, dormant volcano whose gently sloping cone and serrated crater dominate the region.

Simbo is a jagged remnant of an ancient volcano. Its final eruption and collapse to a caldera (large volcanic crater) created a deep and protected harbour. Spikes of black rock in the surrounding sea mark the volcano's earlier size. Simbo is now a solfateric volcano: its surface activity is limited to gas vents, hot sands and springs. When Simbo last erupted just after World War II it destroyed Ovi village and displaced many people.

Ovi village stood around the edges of the crater of a subsidiary volcanic cone in one corner of Simbo, and around the shores of the green crater lake at the base of the volcano. Ovi

people depended upon the volcano. They collected the eggs of the Scrubfowl (*Megapodius freycinet*) for food or trade. Scrubfowls bury their eggs in sands heated by volcanic activity—a natural incubator. The people had little need for fuel: the eggs and vegetables were boiled in hot springs or steamed in gas vents.

The only signs of Ovi nowadays are scattered hut foundations and stone walls in the rainforest that has reclaimed the site. The volcano quickly subsided but the trees have taken little of its land. The crater and much of the lava flow are lifeless. Volcanic rocks, once black, have been gradually transformed to a creamy colour. Yellow smears of sulphur and red coatings of iron oxide paint an erratic mosaic.

The lifelessness, the transformed rocks, and the sulphur and iron deposits have a common genesis. Gases given off by subterranean magma or cooling igneous rocks react with surrounding rocks as they rise to the surface, often taking up sulphur and iron. They emerge at vents, called fumaroles,

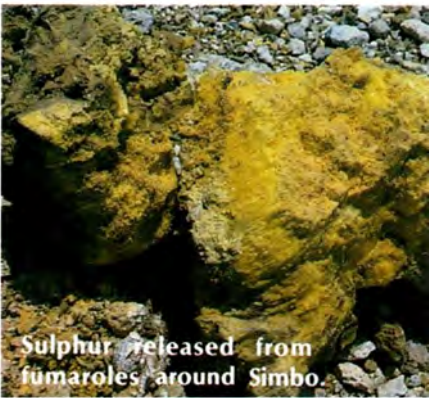
where the minerals precipitate on the surrounding rocks. When these gases combine with water they form acids that break down minerals in the rocks, leaving a creamy-coloured remnant of silica and clay. The rising hot gases heat any water bodies they encounter. The water in the crater lake at the base of Simbo's volcano is uncomfortably hot to stand in. The heat and chemicals released into the water are optimal for algae, which give the lake its characteristic green colour.

When their village was destroyed, the Ovi people moved to the only vacant land that remained on Simbo, at the opposite end of the island, and established Tapurai village. There was no fresh water and they were not fishermen. Fortunately, not all the forest was destroyed by the eruption and each family retained ownership of a patch of Scrubfowl nests.

The Tapurai people travel each day in their canoes to their Scrubfowl nests on the slopes of the volcano. Lunch is cooked in one of the many fumaroles. On their way home they collect fresh



A day's harvest of Scrubfowl eggs.



water from a communal tap in Lengana village. Scrubfowl eggs are their livelihood: they are traded for other foods or taken to Gizo, the provincial capital, and sold at the markets. The people have attempted to guarantee this livelihood by making shelters to encourage the Scrubfowls to nest, but the birds rarely use them. All accessible nests are raided and all eggs taken. As the Tapurai people proliferate and become more efficient in collecting eggs, it is unlikely that the few Scrubfowls that hatch from the inaccessible nests will be enough to support them.

Tinakula

Tinakula is situated in the Santa Cruz Islands, the eastern-most island group of the Solomons. Lata, the main settlement, is perched on the rim of a volcanic caldera, which is now part of the island of Nendo. The people of Nendo live comfortably. Fresh water flows freely from the rock faces in cool streams, and the soils are rich and heavy. The rainforests growing out of the caldera's slopes were the richest I saw in the Solomons. The waters inside

the caldera are sheltered and safe for fishing. The villages are clean and the huts are securely built from broad pandanus fronds. Wherever I walked around Nendo I was surrounded by smiling, curious children.

The active volcano Tinakula lies 15 nautical miles (28.5 kilometres) north of Nendo. Smoke belches constantly from the crater. It is a steep-sided volcanic cone created from the lava, ash and cinders accumulated from previous eruptions.

After 15 years of silence at Tinakula, a violent explosion at 8 am on 29 November 1964 began another phase of activity that lasted until May 1965. There were ash and steam eruptions, and the north-western slope was covered by fresh lava flows. On 28 May 1965 much of the slope fell into the sea in a gigantic landslide. The following tidal wave reached islands 12 nautical miles away.

Six years later Tinakula became active again. At sunset on 6 September 1971 the inhabitants of Nendo were disturbed by a continuous rumbling and dark clouds obscured the volcano.

Is Australia Volcanically Dead?

Most Australians live content in the knowledge that they are safe from the hazards of the volcanoes along the eastern seaboard. Is this a false sense of security? Scientific studies indicate that it is. Australia shelters well behind the active volcanoes of the Pacific margin, which stretches from New Zealand through the Tongan and Solomon Islands into New Guinea. The continent seems serene apart from the odd jolt of an earthquake here and there. Yet almost the entire eastern coast of Australia shows many past outpourings of lavas, some being quite fresh and obviously coming from recognisable volcanic cones and craters.

Some of the volcanoes are well preserved in form, indicating that little has changed since their eruption. Lack of erosion indicates these are certainly less than 10,000 years old. Scientific research also uncovers some disturbing patterns in the ages of the older, more denuded volcanoes.

The largest former volcanoes in Australia—such as Cape Hillsborough, the Tweed Shield, Nandewar Mountains, Warrumbungles and Mount Conobolas—become progressively younger in age the further south one ventures, with each centre erupting in succession every few million years.



Sites of Australian volcanoes. Numbers represent millions of years since last eruption.

This places Tasmania in the hot seat as next in line for such a volcano after Victoria, the last place to experience a large volcano six million years ago at Hanging Rock. Geologists have identified the northern part of Tasmania as the current location for the underlying hot spot that has moved down Australia's eastern coast. Already the ground there is giving off higher than normal heat flows. Discharges of water into mines in Tasmania are bringing up dissolved carbon dioxide from the mantle and there is evidence that the north-eastern corner of Tasmania is tilting and uplifting.

Some geologists predict that this hot spot could cause an eruption, perhaps within the next few thousands of years. It will all depend on the balance of stress on the rocks, either compressing or stretching fractures which would close or open up passage ways to rising lava.

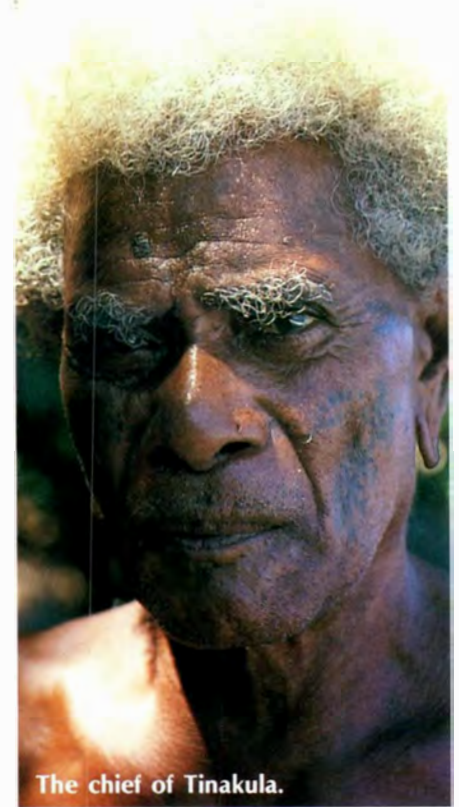
Besides the big centres of volcanic activity, there are several areas of small volcanic cones and lavas that finished erupting only between 4,000 and 20,000 years ago. Any visitors to Mount Gambier and Mount Schank in South Australia (the youngest volcanoes), Tower Hill in Victoria or the Burdekin River near Charters Towers in Queensland can see the evidence—such as craters, young flows and the unworn surface of lava flows—for themselves. So recent are these eruptions that they figure in Aboriginal myths and legends, and explosive volcanic ash beds have buried an old Aboriginal midden site near Warrumbool in Victoria.

So there is certainly no guarantee that all of Australia is volcanically dead. With the spectre that large volcanoes may burst forth in Tasmania, the future appears ashen. Even sleeping giants like incipient volcanoes may eventually wake! □

—Lin Sutherland
Australian Museum



The Polynesian village built on an ash plateau below an old vent on Tinakula.



The chief of Tinakula.

Over several hours the tremors became more intense and flames rose from the crater. When the sea began to recede the people recognised the sign and fled from their villages to higher ground; soon after, all low-lying areas were swamped by a tidal wave. There were four earthquakes, all followed by tidal waves. No lives were lost. The constant eruptions continued until early October and much of the north-western slope of Tinakula was covered by lava. The inhabitants of Tinakula were not rescued for ten days after the initial eruption due to rough seas.

I arranged to visit Tinakula in 1985 and was taken by a guide, Moses, in a canoe. We came ashore on the black-sand beach at the base of the lava flow. Cinders dislodged by gusts of wind rattled down the flow, sounding like dry, brittle bones. Lava boulders that originated from a vent below the main crater bounded continually down the slope. Sudden overflows and gas bubbling through magma pools in these vents threw off lava bombs (blobs of molten lava), the surfaces of which cooled quickly to form a thin rocky skin.

The lava flow is slowly filling the gash in the north-western slope created by the landslide. The forest that covers Tinakula grows to the edges of four-metre high 'walls' that bound the lava flow but the flow itself and the entire north-western slope are lifeless. By contrast the first animals and plants arrived on the blackened remains of Krakatau, a volcano in Indonesia, within nine months of its great eruption in 1883. Twenty-eight plant species had re-established within three years, and after 40 years 573 animal species had returned. Yet, 15 years after Tinakula's last eruption, there was no visible life

on the ravaged slope, despite the surrounding forest and sea from which animal and plant colonists could come. Why? Sporadic ash eruptions and lava flows destroy colonising vegetation and allow little time for the substrate to be consolidated. Together with heavy equatorial rains, the earthquakes that regularly shake these islands cause more landslides. The layer of ash and dust that covers the slope and shifts constantly in the winds, and the continuous cascade of boulders that dislodges seedlings, make plant succession impossible.

The Polynesian inhabitants of Tinakula built their village on the only flat piece of land—a cliff top plateau on the southern rim of the island, in the shadow of a dormant cone below the main crater. Moses and I were invited to the village where we sat on woven mats laid out on the dusty ground in the shade. The people and the fruit they gave us were covered by black dust. The children clung to their parents' legs and stared quietly. The problem of a lack of running fresh water had been solved: coconut fronds plaited around the smooth trunks of betel nut trees gathered rain water and funnelled it into buckets. Unlike Nendo, the village architecture reflected a lack of quality building materials and the uncertainty of life on an active volcano. The huts, built from narrow coconut fronds, were small, untidy and appeared unstable.

The ancestors of Tinakula's people had witnessed many volcanic events and incorporated them into their myths. The story of the origin of Nendo seems based upon accounts of the formation of volcanic islands; Moses translated for me:

"Two brothers from the Duff Islands

went out in a canoe one day to search for spirits. Coming to a place where they heard the spirits singing, the younger brother leapt into the sea with a rope. He swam to the bottom and tied it; the older brother hauled on the rope. The sea became very rough. Mountain peaks rose from the water and finally an entire island emerged."

A traditional story was also told that explains the origins of some of their customs. The story described two sisters who had fled to Tinakula to escape their brother's murderer. In grief, they decided to wear clothes at all times and only eat in the mornings and evenings. Upon their deaths the sisters were changed into rocks perched on the crater. The people of Tinakula said that to this day they always wear clothes and eat their main meals in the mornings and evenings.

Life on active volcanoes is a constant risk. Plant and animal communities that were established over many years can be destroyed overnight, and then barred from their former habitats by lingering gas clouds and ash storms. Able to alter their circumstances, people of volcanoes develop a livelihood suited to the constant threat of eviction. Ironically, like the people of Simbo, that lifestyle can become dependent upon the force that threatens them. The future of people living on volcanoes will ultimately depend upon their ability to survive the changes presented to them by the volcanoes. □

QUIPS, QUOTES & CURIOS

Lover's Darts

The mating behaviour of the humble garden snail (*Helix aspersa*) is curious indeed. Along with other species of helicids and several other families of hermaphroditic land snails, they thrust calcareous darts into the bodies of their mating partners during courtship. What to us would appear an immediate turn-off is, for the snails, quite the opposite.

These darts are housed in an internal dart sac, which is associated with mucous glands. The darts can be extraordinarily long in relation to body size and, in *H. aspersa*, may measure some eight to ten millimetres, weighing on average about two milligrams. The dart in *H. aspersa* tapers distally to a fine point and has four longitudinal ridges that act as cutting blades, making penetration through flesh easier. The darts are jabbed from close range, sometimes with such force that they have been found deeply embedded in the snails' internal organs. Usually, however, they merely prick the skin and fall to the ground.

The dart apparatus has

been attributed various functions since it first became known to scientists, well over a century ago. One now-defunct hypothesis, that the darts were used as weapons of defence, stemmed from observations of deeply embedded darts. However, because of its use in courtship, it appears most likely to be associated with some sort of stimulatory function.

Daniel Chung, from the University of Michigan, has devoted much of his time to the study of dart shooting behaviour in *H. aspersa*. Apparently virgin individuals do not possess darts yet they still go through dart shooting behaviour during courtship. Only after going through this initial dart shooting behaviour do they start growing a dart (*J. Moll. Stud.*, 1986, vol. 52, p. 253).

Loss of a dart, which occurs only during courtship, triggers formation of a new dart. They are replaced within five to seven days after being expelled from the dart sac. Snails that have mated recently and do not yet have a fully-grown dart in the dart sac can mate again, but those snails do not go through dart shooting behaviour.

Dart shooting behaviour and expulsion of a dart depends only on the internal condition of the snail and not on its partner's condition or behaviour. Thus in many but not all courting pairs, both snails shoot darts (depending on their condition) but it is rarely simultaneous.

Chung set out to prove the hypothesis that the dart of *H. aspersa* is used to inoculate its mating partner with a stimulatory substance that is secreted by the mucous glands associated with the dart apparatus (*J. Exp. Zool.*, 1986, vol. 238, p. 129).

In this study, extracts of the mucous glands were injected into adult *H. aspersa*. These animals responded by everting their penes and so too did those that were injected with mucous scraped from recently spent darts. In contrast, snails injected with tissue from non-genital areas showed no response, indicating the active substance is secreted by the mucous glands.

The active substance is a 'contact' pheromone, that is it requires physical contact to work. Surface-smearing of the mucous gland extract was not effective, however, so it seemed that it must be injected to induce genital eversion.

The secretion of a contact sex pheromone has been confirmed in only one other species of pulmonate land snail. The head wart in the Japanese snail *Euhadra peliomphala* secretes a substance that elicits initial genital eversion. Dart shooting in *H. aspersa* occurs naturally only after initial eversion of the penes during courtship, so the role of the active substance in this species appears to prolong eversion (not to initiate it) and thus increase receptivity to sperm.

Supplementary genital structures have long been

hypothesised to help in species recognition. This, however, is unlikely because when the extract from *H. aspersa* was injected into a related species, *Cepaea nemoralis*, a positive reaction was recorded. —G.H.



The Emu.

WILD NATURE, ANT

Alias Emu

There are few birds more characteristic of Australia than the Emu, yet the name is derived neither from the country's Aboriginal nor European inhabitants. The fascinating and rather convoluted origin of this title for an endemic bird has recently been traced by J.D. Macdonald (*Sunbird*, 1986, vol. 16, p. 68).

The term has its roots in the Arabic name for Ostrich, formerly found on the Arabian Peninsula but now restricted to sections of Africa south of the Sahara. A transliteration of the Arabic word into English is Na'ama, pronounced 'na-ema'. (There is a similar word in Hebrew which translates as 'greed' in reference to the rather indiscriminate feeding habits of the Ostrich.)

During the Moslem occupation of the Iberian Peninsula in the seventh to ninth centuries, this name, like many other Arabic words, became incorporated into the local languages. However, in the transition it became a general term for large birds rather than being reserved for a specific, non-



The humble garden snail (*Helix aspersa*).
Inset: darts of *H. aspersa*.

KATE LOWE



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European species.

After the Moslem retreat, the fortunes of Portugal and Spain rose. They rapidly emerged as major seagoing powers and in 1485 agreed to divide the world into two parts to avoid conflicts between their rapidly expanding explorations. In this division, it so happened that Portugal gained access to parts of the globe in which other large, flightless birds were found—Brazil (rheas) and the East Indies (cassowaries). (Australia and the Emu were not known at this time.) Each large bird of the Portuguese regions was given a variant of the name *ema*; conversely in the Spanish territories, where no similar birds existed, this term was lost, probably through disuse.

When the Dutch moved into the East Indies in the 1600s, they too adopted, from the local usage, a variation of *ema* for the cassowaries. Gradually, however, this was replaced by a title from the Papuan words *kasu* (horned) and *weri* (head), eventually becoming 'cassowary'. Both 'emu' and 'cassowary' were used by the Portuguese and Dutch explorers for the cassowaries and these alternatives were adopted by the early English colonists to Australia. Although missed by Captain James Cook, the Emu was soon encountered by members of the First Fleet who

employed for it the terms 'New Holland Cassowary' and 'Emu'. Its similarities to the South American rheas were recognised and the continued use of the term 'Emu' for the New World bird may have been instrumental in its consequent replacement in the early nineteenth century of 'cassowary' for the Australian bird.

—Walter Boles
Australian Museum

Animal Airstrikes

Ever since aviation began, animals and planes have been colliding. Aviation departments around the world regard birds, in particular, as a serious threat to aircraft safety. A two-kilogram bird colliding with an aircraft travelling at 135 knots (about 250 kilometres per hour) can have an impact force of 3.8 tonnes. That kind of force can cause serious damage to aircraft and cost lives (human and other!).

Galahs, kites, hawks, gulls and plovers are the most commonly struck birds, although bats can also be a problem as they fly in large groups. Flying foxes, in particular, have been hit when they cross the runways at Brisbane airport, however the timing of their movements is more predictable than that of many birds. Birds of prey are sometimes known to attack aircraft—they are territorial



crop duster, flying at low altitude, collided with morant weighing 3.5 kilograms.

COURTESY BUREAU OF AIR SAFETY INVESTIGATION

Compiled by Georgina Hickey

and see anything flying through their area as a threat.

While 97 per cent of birdstrikes occur at or near aerodromes, mostly at low altitudes (under 1,000 metres), many birds soar much higher. The world's highest recorded birdstrike was at 11,300 metres above sea-level between an Israeli aircraft and a Ruppell's Griffon (*Gyps rueppellii*), a large vulture.

Many methods of removing birds from around aerodromes have been attempted. These include the birds' own distress calls being recorded and played back, strobe lights on planes, gas canons, bells, flare guns, killing or trapping the birds, removal of habitat, introduction of birds of prey, stuffed bird corpses that act as 'scarecrows' (these tend to get very soggy and lose their shape after a couple of rainstorms), spraying grassed areas around runways with insecticide to kill the insects that attract the birds, and regularly coating potential perches with sticky substances or attaching spikes to prevent birds from roosting. Most of these methods, however, have had little success on their own as birds get used to visual or sound effects and stop responding to them unless their position and method is altered regularly. One airport in France, in a drastic measure, found that playing Shirley Bassey records at loud volume helped for a while.

But birds are not only a problem in the air. They, along with wasps and mice, also build nests inside planes. Undetected, the nests may block fuel tank air vents or may be ingested into the engine, causing engine failure. Even the lowly earthworm can be a hazard. At London's Heathrow airport large num-

bers of worms are driven out onto the runway after heavy rain. Not only does this attract birds – excessive numbers can reduce the braking efficiency of landing aircraft.

On the ground, stock, kangaroos, wombats, rabbits, emus, foxes and dogs have all been hit by planes. The kangaroo problem at Moruya airport in New South Wales requires a few to be shot every couple of weeks to clear the runway and discourage others. Many country airstrips are grassed and must be mown regularly. The freshly cut grass attracts many animals, which are especially a problem at night as they are difficult to see. Buffalo are a big problem in the Northern Territory; in the USA it is deer; in Fiji, donkeys; in the USSR, elk; and in Alaska, moose.

Strong updrafts and tornadoes have been responsible for some very unusual airstrikes. Planes have been known to collide with frogs or fish at high altitudes. They get sucked up in a tornado or waterspout that may lift them to a height of 6,000 metres! A small frog can get tossed about at that height for several hours by air currents before it finally comes back down to earth.

A particularly bizarre mid-air collision was reported in the USA to have occurred with a snake. Apparently it was being carried by an eagle, which, frightened by the plane, dropped its catch into the flight path! Recently, a light aircraft crash was indirectly caused by a green tree frog in Queensland. The frog had been stuck in the plane's exhaust system and sizzled while the plane was airborne. The pilot, thinking the odd smell was the engine on fire, attempted an emergency landing and crashed.

—F.D.

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The Enchanted Isles

To visit the islands of the Galapagos is to come away with a deep interest in nature. This is the opinion of The Australian Museum Society (TAMS) group that visited these islands in late 1986. Once known as 'The Enchanted Isles' they were the haunt of buccaneers and whalers, who came not in search of natural history enchantment but for the food provided by thousands of Galapagos Giant Tortoises (*Geochelone elephantopus*). So the 'enchanted isles' became known as Galapagos, Spanish for tortoise.

Then came the turn of the naturalists of whom Charles Darwin was the most famous. Back in England from a world tour his thoughts turned on the problems of how evolution could have shaped the world of nature we know today. Discussions with his naturalist friends over the significance of many of his Galapagos and other observations, led to his famous book *The Origin of Species*, a work that was to shake the world of ideas as no other book has ever done. Fascinating plants and animals live in this group of volcanically-formed islands lying across the equator 1,000 kilometres from the coast of Ecuador. The islands never had any land

connection with South America; all their wildlife either flew, floated or swam there. Humans added a more disastrous quota in the last few hundred years in the form of the goats, pigs, dogs, cats and rats that are devastating some of the wildlife today.

Fortunately the magic remains. Only 25,000 visitors are allowed each year so there is little chance of the islands being 'loved to death' by tourists. Indeed we only met one other group. Each party has a knowledgeable guide, skilled in both natural science and languages. Every guide enforces strict conservation rules and no plants may be picked and no animal may be touched. Paths show where you can go.

The animals ignored us except when they actually nested or sat on the pathways and refused to allow us to pass. One TAMS member came too close to a Blue-footed Booby (*Sula nebouxi*) and found that the huge bill could inflict a nasty wound!

We travelled on a small boat, the *Isabela*, that held only our group. We moved during the night and each day visited one or two of the islands. Some of us explored under water; swimming with seals and penguins is an unexpected experience.

After dinner we learned of the pleasures in store for us next day and went to sleep dreaming of Greater

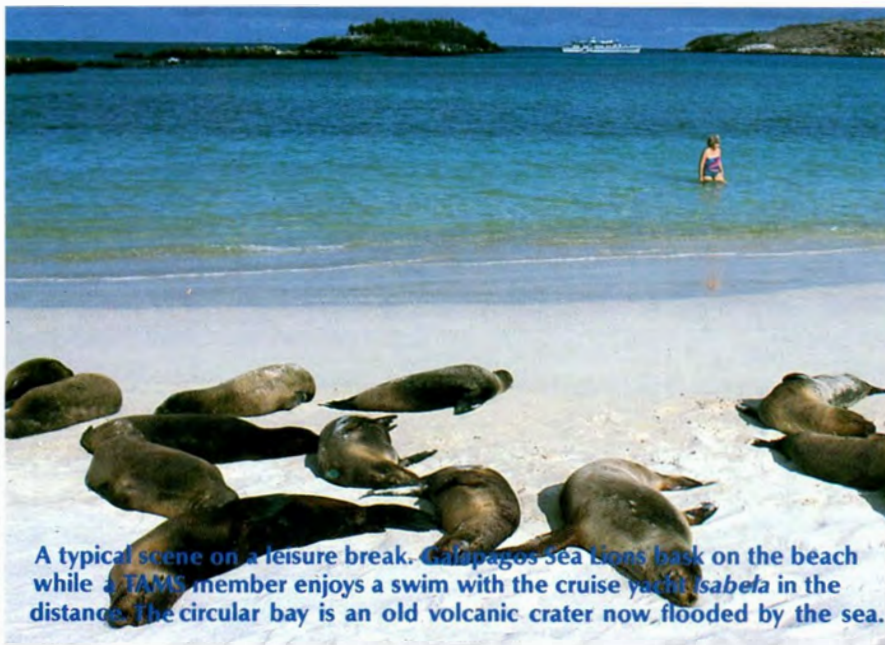


Frigatebirds (*Fregata minor*) displaying their red courtship throat pouches, the awe-inspiring charges of the male Galapagos Sea Lions (*Zalophus wollebacki*), the awkward comical courtship dance of the Blue-footed Boobies, the beauty of Red-billed Tropic Birds (*Phaethon aethereus*), the prehistoric solemnity of hundreds of Marine Iguanas (*Amblyrhynchus cristatus*) and the stately dance of the Waved Albatross (*Diomedea irrorata*).

Seals, seabirds and landbirds were among the major wildlife attractions but most of the TAMS group were enthralled by the reptiles, the Marine Iguanas in particular.

The first Marine Iguana we saw crawled like a coal-black dinosaur across the sand. It was much photographed, although later we realised we had wasted a lot of film as we found these lizards on most of the islands and often in groups of several hundred.

We saw them soaking up the sun on the volcanic rocks, nibbling at green seaweed at low tide and plunging into the water to feed under the sea. A Marine Iguana can stay under water for nearly an hour so these are reptiles ideally suited for feeding on seaweeds. The tail is the swimming organ and the lizard uses its webbed feet with sharp



A typical scene on a leisure break. Galapagos Sea Lions bask on the beach while a TAMS member enjoys a swim with the cruise yacht *Isabela* in the distance. The circular bay is an old volcanic crater now flooded by the sea.

PHOTOS: VINCENT SERVENTY

OF



VINCENT SERVENTY



Marine Iguana.



The Saddleback variety of Galapagos Giant Tortoises.

claws to cling to rocks when waves wash them. Marine Iguanas vary from very dark to attractively coloured with mottlings of red and orange, green front legs and green crests. We never tired of them.

The Galapagos Giant Tortoises are truly gargantuan with individuals weighing up to 230 kilograms. Thirteen subspecies are found on the islands, although some scientists believe that, like the famous Darwin finches, they should be considered full species. In the early days of the discovery of the Galapagos, hundreds of thousands of tortoises were taken on board sailing ships as fresh food and it is estimated there are only 6,000 to 10,000 left on the islands.

Broadly speaking the tortoises from the larger and wetter islands with plenty of plant food have dome-shaped shells. Those on the drier islands have long, thin legs and strangely shaped shells with a dip in the neck—these are referred to as the 'Saddlebacks'. Such a shape allows a longer stretch of the neck so an animal can browse on tree cactus (*Opuntia* sp.) a common food plant in more arid places.

There is still argument as to how such reptiles reached these volcanic islands so far offshore. On rare occasions

Galapagos Giant Tortoises have been found many kilometres out to sea so it is possible that some drifted on ocean currents to reach the islands. A more likely explanation involves rafting. The large rafts of vegetation that often wash downstream and into the sea most probably carried a number of them.

Yet even in paradise there are problems. We noticed three.

Firstly, the graffiti daubers have been at work on many of the islands. There was no evidence that the authorities were going to remove these blemishes, although there are regulations forbidding the practice. Secondly, the small town on Santa Cruz, due to what seems to be a complete lack of planning, is a blemish on the beauty of the

island itself and the group as a whole. The third problem is more serious. The recovery of the wildlife depends on the removal of as many of the intruding animals and plants as possible. This needs money, and the staff at the Charles Darwin Research Station showed little interest in educating the tourists on this problem.

We intend to send a letter to the President of Ecuador on these topics. There is nothing like a foreign letter to bring action as we found on a previous TAMS visit to India. A suggestion sent to the then Prime Minister, Mrs Indira Gandhi, regarding the famous Bharatpur wetlands, brought a prompt response and action. So TAMS plays its part in international conservation. □



Camels

Humpbacks of the Desert

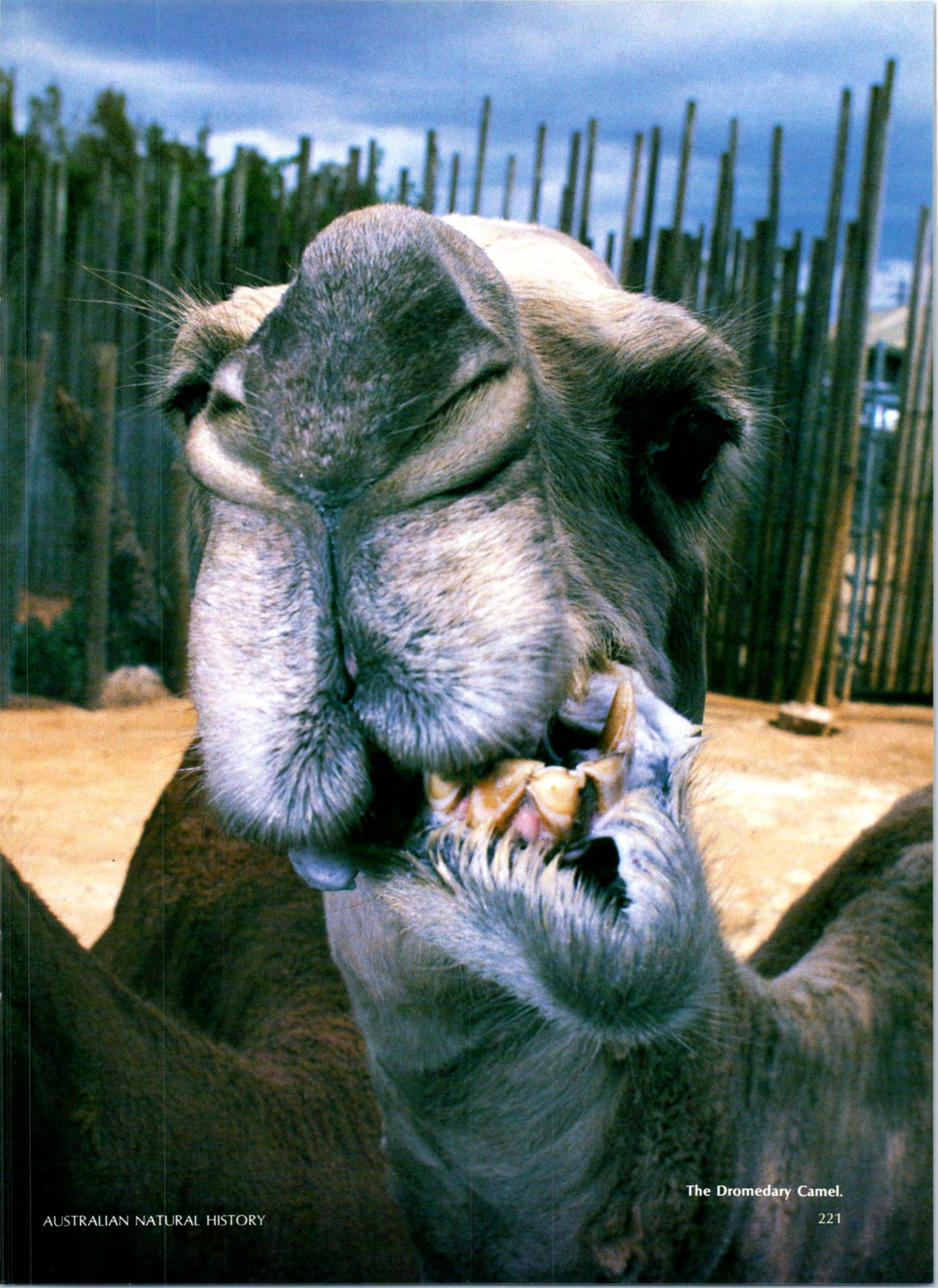
By Gordon Grigg
School of Zoology
University of Sydney

"At first they are queer, awkward, slow, hard to understand, stupid, smelly, unapproachable and unfriendly, horribly noisy with their awful groans at loading time, generally repulsive, and trying to the nerves of anyone in a hurry... the whole process of travelling by camel seems antiquated and exasperating. But when the thermometer begins to pass 100° day after day, when the feed disappears, and only dry brambles can be found, and, finally, when water and the possibility of water become nothing but a wild hope, then the camel comes into his own. There he kneels, uncomplaining and unconcerned, a tower of strength and comfort, living on the fat of his hump, and good for another 200 miles."

Explorer Charles Madigan,
Central Australia, 1836.

Many people are surprised to hear that Australia has a large population of feral camels. They were introduced mainly between the 1860s and the turn of the century for use as work animals in the inland. With their ability to cope with poor feed, shortage of water, high temperatures and sandy substrates, camels made ideal work animals in our arid interior and contributed significantly to its exploration and development. With the arrival of motor transport, many were turned loose to become the

KATE LOWE



ancestors of today's herds. Despite their extensive use throughout Australia for more than 60 years, little has been written about them or their 'Afghan' drivers. Two books, however, stand out as fascinating reading: H.M. Barker's *Camels and the Outback* (1964) and T.L. McKnight's *The Camel in Australia* (1969). This article will outline some aspects of the biology of camels, their contribution to Australia and their contemporary ecological significance.

History of Camels in Australia

All Australian camels are Dromedaries, *Camelus camelus dromedarius*, with a single hump. Most of them were shipped from Karachi, Bombay or Calcutta and presumably originated in Baluchistan (now a province of Pakistan), Rajasthan (northern India) and neighbouring areas. The natural distribution of Dromedaries is uncertain because they have been domesticated for at least 5,000 years, associated mainly with the peoples of the warm sandy countries in south-western Asia and northern Africa. The other Old World camel, the two-humped Bactrian Camel (*C. c. bactrianus*), prefers colder, rocky areas and occurs naturally in Mongolia

and the steppe country in south-western China. It is often domesticated throughout central Asia.

The only other living members of the family Camelidae are four species in the New World—the Alpaca, Vicuna, Llama and Guanaco in South America. This disjunct distribution may seem odd but is resolved by consideration of the fossil record, which suggests that camelids evolved in North America some time in the Eocene, and then diversified and spread into South America. In the Pleistocene they apparently migrated across the Bering landbridge to Asia, Europe and North Africa, extinction occurring in North America. The six surviving species are all that remain of a diverse and widespread group with at least 20 known fossil genera. With its long isolation, Australia is perhaps the least likely continent to have camels at all, yet it is here that most of the world's undomesticated camels now occur.

How has this come about? The long association between camels and man is easy to understand. They are tractable (in skilled hands) and useful not only for pulling or lifting loads but also for their wool, leather, meat and milk. Their abilities in hot dry country made

them a logical choice as a domestic animal for pre-petrol-driven Australia. The first camel into Australia was a survivor of a shipment of several from the Canary Islands, which landed at Adelaide in 1840. Subsequently this animal was used by the Horrocks brothers in an exploration of country to the west of Lake Torrens in South Australia, becoming the first of many camels to contribute to the exploration of our desert areas.

The push for more camels to be imported came mainly from South Australia, Adelaide being the closest settlement to country where camels would be useful. The prime mover in importing and later breeding camels was the pastoralist Sir Thomas Elder who brought in not only the camels but skilled handlers as well—the well-known 'Afghans', most of whom were not from Afghanistan at all, but from Baluchistan and Rajasthan. Elder started a camel-breeding station at Beltana, a still-famous sheep property several kilometres south of where Leigh Creek is now, which also became the headquarters of a general cartage company using camels. With their much admired but downtrodden and insular 'Afghan' handlers, working camels rapidly became a significant and familiar sight throughout inland Australia. Not only in exploration, but in the major inland construction work of the time, there was a reliance on camels: the Overland Telegraph Line (1870–72), the Transcontinental Railway (1912–17), the extensive vermin-proof fences along State borders and at the margins of the pastoral country, and the pioneering of the Canning Stock Route.

For 50–60 years camels provided the life blood of the developing pastoral industry in the arid lands, numbers peaking at 20,000 or so in 1920. Then their usefulness came to an abrupt end with the arrival of motor transport. Barker's book provides a fascinating perspective not only of the use of camels but also of early pastoral life. He tells poignantly about the end of the camel work and recognised that something very special was departing the Australian scene. Unwanted camels were either shot or released and the survivors bred and dispersed throughout any suitable habitat.

Among people familiar with camels, the beasts seem to have always raised strong although mixed feelings. Perhaps it is the aloofness they seem to show, or their characteristic unbending independence that disturbs so many observers. Opinions differ about their tractability. Many authors have reviled



JEAN-PAUL FERRERO, AUSCAPE

Camels are tractable in skilled hands.

them for their intransigence, their habit of spitting green saliva, their discomfort as a mount, their smell, their untrustworthiness and their general unsociability. Barker, on the other hand (who might almost, from his writing, have preferred camels to people) wrote charmingly about their willingness to work, their prodigious abilities at pulling and lifting, and their intelligence.

They undoubtedly deserve this admiration, if even half of the feats reported of them are true. Madigan writes that a load of 500 pounds (about 200 kilograms) is commonplace on a pack animal, with loads of 1,440 pounds (650 kilograms) possible—the equivalent of four bales of wool. As for distances travelled, McKnight reports an ‘Australian record’ camel ride of 224 kilometres in a single day. He regarded rides of 80–100 kilometres per day as commonplace. Other famous rides are that of an ‘Afghan’ taking a ballot box 450 kilometres from Innaminka to Farina in South Australia in less than three days, and a famous race between a camel and a horse over 176 kilometres from Bourke to Wanaaring. Both made the distance between sunrise and sunset, the horse winning narrowly. But the horse died the following day, while the cameleer Abdul Wadi rode the camel back to Bourke the next day. Distances of 50 kilometres per day are more the norm for riding camels, however.

Madigan (1936) apparently considered the speed of a pack camel to be one of life’s constants. He allowed “two and three quarter miles per hour. . . and [would] not be a mile out in a hundred”. He conceded that “this does not apply to a trotting camel, which can be urged to a faster pace”. (Madigan, I feel sure from his writing, was a man of fixed ideas. I once met one of his camel drivers on the Simpson Desert crossing. He was a part-Arunta-part-Afghan’ called Walter Smith, then in his 80s and retired in the Hartz Ranges. He told me with much laughter and elaborate mimicry how Madigan always went in straight lines, following the compass, even if a hill got in his way. Walter had apparently attracted a severe reprimand for going around a small hill on one occasion and, after more than 30 years, the reprimand still rankled!)

Camel Survival Tricks

The suitability of camels for desert regions comes from their ability to cope with the two main stresses of deserts—high temperatures and a shortage of water. Indeed, these are synergistic in their action because the only way for warm-blooded animals to cool in am-

Camel Stew

On explorations into Australia’s arid interior, camels did provide, however reluctantly, the occasional life-saving meal for the explorers. Peter Egerton Warburton, for example, in his *Journey Across the Western Interior of Australia* (1875, p.217) didn’t waste a scrap:

“The inner portions of the beast were first eaten, not the liver and other dainty parts only, but all, every single scrap was greedily devoured, and whenever eating is mentioned, it must be taken au pied de la lettre, and not with the loose signification we attach to it in England; to eat a bird meant with the explorer to pluck him and then to eat him right through, and to eat a camel meant exactly the same thing. No shred was passed over; head, feet, hide, tail, all went into the boiling pot, even the very bones were stewed down for soup first, and then broken for the sake of the marrow they contained. The flesh was cut into thin flat strips and hung upon the bushes to dry in the sun, three days being requisite to effect the process properly. The tough thick hide was cut up and parboiled, the coarse hair was then scraped off with a knife, and the leather-like substance replaced in the pot and stewed until it became like the inside of a carpenter’s glue-pot, both to the taste and to the smell. Nourishment there was little or none; but it served to fill up space, and as such was valuable to starving men, who could afford to discard nothing. The head was steadily attacked and

soon reduced to a polished skull, tongue, brains, and cheeks all having disappeared; the foot was much esteemed as a delicacy, though a great deal of time was requisite to cook it to perfection

“Out of the whole number of camels killed for food . . . not one threw to the surface of the cooking bucket a single particle of fat. Worn out and diseased, they afforded no more nutriment than is found in the bark of a tree, and yet on such wretched stuff the party preserved their lives for many weeks. Poor as it was, it was their all, and without it they must have infallibly perished.”

On a lighter note, we’d like to share with you this recipe for a gastronomic delight:

3 medium-sized camels
1 ton salt
1 ton pepper
500 bushels potatoes
200 bushels carrots
3,000 sprigs parsley
2 small rabbits

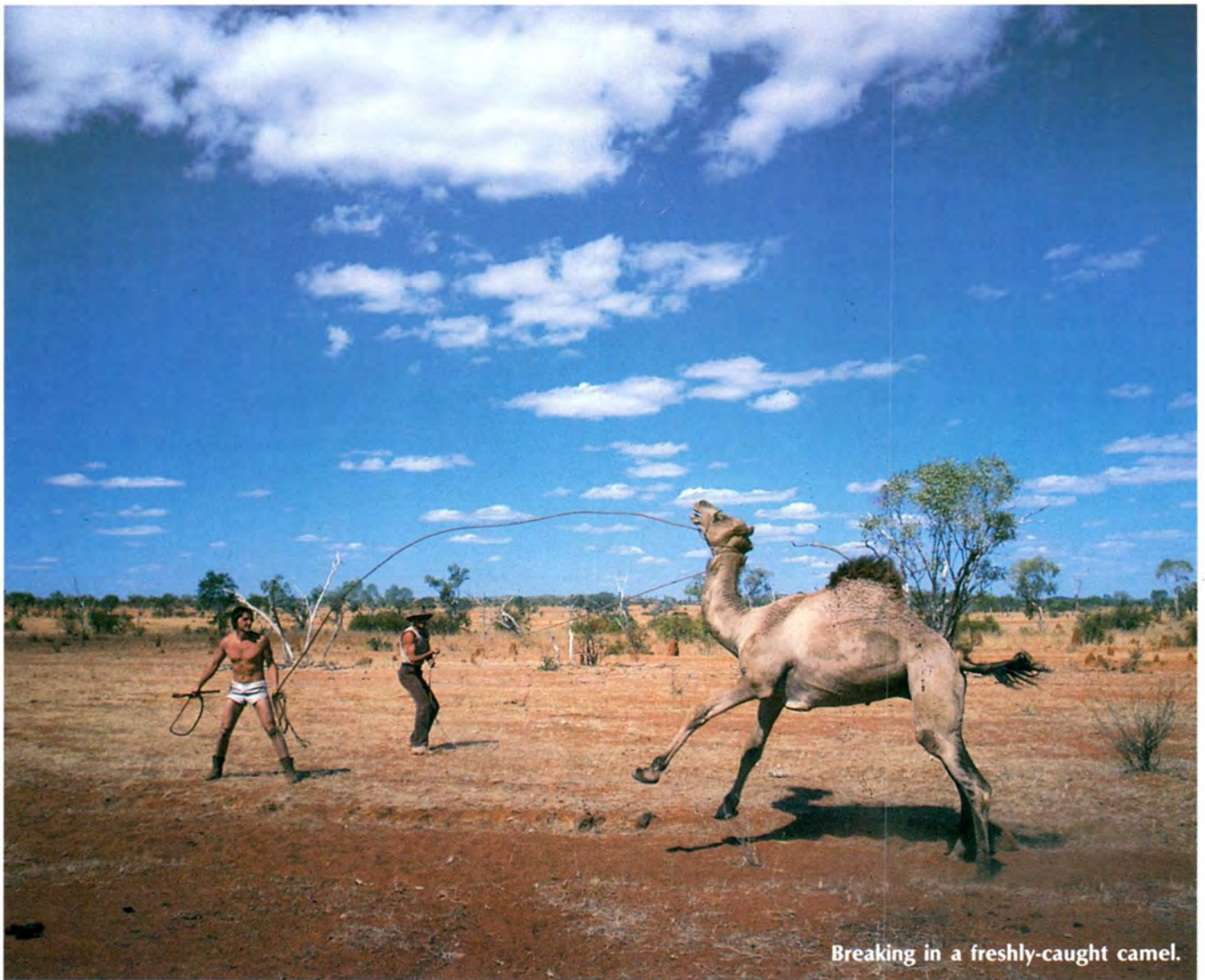
Cut camel into bite-size pieces. This should take two months. Cut vegetables into cubes (another two months). Place meat in pan and cover with 1,000 gallons of brown gravy. Simmer for four weeks. Shovel in pepper and salt to taste. When meat is tender, add vegetables. Simmer slowly for four weeks. Garnish with parsley. Will serve 3,800 people. If more are expected, add two rabbits. [Source unknown]. □

bient temperatures close to or above their body temperature is by the evaporation of water vapour on a moist surface. Evaporative cooling by sweating is usually a luxury that a desert mammal cannot afford and camels are no exception. Instead they have physiological capabilities and behaviour that enable them not only to survive in hot, dry deserts but to work and travel as well.

One thing camels have going for them is their large size. This gives them a small surface-area to mass ratio, which means that their body temperature has more inertia than a small animal. They have a lower metabolic rate and a lower loss of water across the skin and lung surfaces per unit weight than smaller animals, so a camel takes longer to dehydrate and longer to warm up.

The camel’s thermal inertia is enhanced by an insulating coat of hair, thicker on the upper surfaces. The emi-

nent Danish animal physiologist Knut Schmidt-Nielsen, showed the importance of the coat as an insulating layer by shaving a camel. The camel produced 60 per cent more sweat than an unshorn one. He found also that camels play a significant physiological ‘trick’ by letting the body temperature rise each day. Most warm-blooded animals maintain a very stable body temperature. A man in the desert, for example, soon starts sweating when ambient temperature rises, in an attempt to keep the body temperature constant. Camels, however, are able to tolerate a wider range in body temperature. In the heat, but with abundant water, Schmidt-Nielsen found that a camel showed daily fluctuations in body temperature from about 36°C in the morning to 38.5°C later in the day. In comparison, a camel deprived of water started each day cooler (34.5°C)



Breaking in a freshly-caught camel.

and tolerated a rise to nearly 41°C. By storing heat and tolerating the temperature rise, water is saved that would otherwise have had to be expended in evaporative cooling. Schmidt-Nielsen calculated that this strategy saved the camel about five litres of water per day. At night, of course, the stored heat is lost to the cooler surroundings. The as yet unknown biochemical explanation for this heat-tolerant phenomenon would make an interesting study project.

Apart from coping with high temperatures, the other physiological skill of camels is that they can go such a long time without water. They can do this because of their large body size and because they avoid the use of water for evaporative cooling, as discussed above. However, this is only part of the story for they also have a prodigious ability to tolerate dehydration. Whereas we die if we lose water equivalent to 10–20 per cent of our body weight, camels tolerate losses of 27 per cent without ill effect. Camels can also tolerate rapid rehydration when water be-

comes available. Gauthier-Pilters and Dagg, working in Mauritania, northern Africa, found that camels often drink at 10–20 litres per minute, with a maximum of 28 litres per minute. Dehydrated camels may drink 25 per cent of their body weight at rehydration. In typical mammals, such a flood of water entering the bloodstream from the stomach would cause the rupture of red blood cells by osmosis. In camels, however, workers in Israel have shown that the red blood cells are sturdier and do not burst. Also, the kidneys are very competent and can go from producing a dark, thick, syrupy liquid to a thin, watery urine in the space of 30 minutes or so.

Contrary to popular belief, camels do not drink and store water in anticipation of a need. In moderate temperatures, camels may not drink at all, gaining sufficient moisture from succulent food. At 30–35°C, they may drink every 10–15 days, depending on activity. Frequent watering seems to be necessary in temperatures consistently above 40°C, however there are so

many variables that no hard and fast rules can be laid down. Obviously one significant factor will be the night as well as the day temperatures.

Another fallacy that must be referred to is the frequently encountered belief that camels store water in the hump. The hump is an important energy store, as fat, and its size is a reasonable guide to the fitness of its owner. Certainly the metabolism of fat does produce some water, called 'metabolic water', but this is trivial in the overall water economy of camels.

Apart from their water and temperature relations, camels have other attributes that equip them excellently for life in hot, dry deserts. Their long legs enhance mobility and the soft, enlarged foot pads are ideal for walking on sand substrates. Long lashes keep blowing sand from the eyes and the slit-like nostrils, together with the fringe of nose hairs, probably filter air in the event of a sandstorm. (Perhaps somebody could confirm this by following the experimental lead of Schmidt-Nielsen and study a camel in a sandstorm with its

nostrils shaved?)

Distribution, Abundance and Impact

How many camels are there in Australia and what is their distribution? These are questions asked commonly, but the answers are not easily found. McKnight tried to come up with answers by questionnaire, interviews and travel. They occur in all Australian States, except New South Wales, Victoria and Tasmania. He estimated a population of 15,000 to 20,000 in 1966. Aerial survey would seem to provide the best possibility of making an estimate, as with kangaroos. Indeed, we always note all camels seen during aerial surveys for kangaroos and recently Short, Caughley, Grice and Brown from the CSIRO's Division of Wildlife and Rangelands Research have put together from such data a minimum estimate of 43,000 camels (*J. Arid Environ.*, in press), about twice that of McKnight's estimate. However, because of their cryptic colouration, camels are surprisingly difficult to see from the air and how large a correction factor should be allowed to account for individuals present on the flight transect but not seen is unknown.

By all accounts, camel mating is wondrous to behold. R.T. Wilson in his book *The Camel* (1984) described males in the rutting season becoming hostile to each other and difficult to control. In a group, one male will establish dominance. Wilson notes (p. 91): "Males in full rut grind their teeth, suck air, belch, draw the head back, lash the tail, crouch with jerky movements of the tail and generally make themselves look ridiculous". Frequently they evert from the mouth a fleshy bag, the *dulaa* or *pelu*, which is an air-filled extension of the soft palate. In females, oestrus lasts three to four days and is followed (if fertilisation does not occur) by anoestrus of 10–25 days depending on the season and location. Females in oestrus are usually very receptive, often lying down if a male approaches. Males are attracted by visual and olfactory cues. Copulation typically lasts 10–20 minutes but bouts may be repeated all day. Wilson again notes (p. 94): "Conclusion of the act is accompanied by much bellowing, gurgling and frothing at the mouth by the male and a more or less continuous bleating by the female".

Ovulation is stimulated by copulation and the gestation period is 13 months. A young calf may weigh 25–50 kilograms and suckles within a couple

of hours after birth. Puberty in males is at about three years but they only start to serve females when they are between six and eight years old, and continue to do so until they are about 20. Females are likely to calve when they are four to five years old and may breed until they are 20 or even 30. They may live to 40 years.

Are camels harming Australian habitat? Because so many of Australia's exotic ferals have done irreparable damage to our habitat and wildlife, it is reasonable to worry about the possible impact of animals as large as camels. Also, are they pests where they occur in grazing country? These questions were addressed in a Northern Territory Government enquiry into feral animals there, chaired by Goff Letts in 1978–79. Usually camels are found in areas where there is little grazing by domestic stock, and travel in small family groups rather than in large herds. However, during droughts they may form into large mobs that can be very damaging to fences, particularly around watering points. This is the main problem identified by pastoralists and local control is often undertaken by

shooting.

Various features of camel behaviour and diet are such that severe damage to habitat is not likely. They eat shrubs and trees rather than grasses, so there is little likelihood of competition with domestic stock in areas where both occur, except in drought. Apparently they do not linger around watering points the way stock often do, so are less likely to cause local denudation. Also, the feet are large, soft pads and cause little injury to the habitat, although camel pads are a definite feature in camel country. They are reported to move extensive distances while foraging, 50–70 kilometres per day (but see box), nibbling rather than tearing at shrubs and trees, which suggests that they may not cause significant long-term damage. However, the evidence for many of these statements is subjective rather than objective and more work is needed. Some concern has been expressed that their predilection for certain species of shrub or tree may threaten extinction but once again hard data seem to be lacking. Two German university students are presently engaged in a study of camel social be-

Sexy Blatherers

The blathering habits of sexually aroused camels may stun or even revolt the unaccustomed human observer. Jeremy Leggett describes his experience with a Dromedary Camel while on a field trip in Baluchistan, Pakistan (*New Scientist*, 22 May 1986, p. 61):

"Giving a reverberatory, rumbling groan, a camel near me extruded from the side of its mouth a slimy, pinkish grey sac about the size of a small football, and apparently blown up with air. I was astonished. It looked as though it was trying to throw up its own stomach. After exhibiting this object for about 30 seconds, the camel tilted back its head, and, as though with an effort, returned the sac to its mouth, swallowing noisily and looking more than usually disdainful as a peristaltic wave passed down and round its U-shaped neck.

"One of the camelmen, noticing my look of revulsion, volunteered that this object was in fact the camel's tongue, the blathering extrusion of which was a feature of the 80-day phase of sexual activity (or, in the case of these tethered beasts, sexual aspirations) which camels enjoy each year

"The reluctant camel [having been pulled down to its knees by the load-

er] . . . opened its mouth, exposing teeth coated in greenish grey slime and lips flecked with pea-green foam, and made a noise like the ones you hear in the students' union bar on the night of a rugby-club victory. The result, in the case of the camel, was a spray of green slime most of which splattered over the torso of the loader. I watched horrified as the Baluch made little or no effort to wipe away the offending substance. This was clearly a regular occupational hazard.

"Yet I had heard from Arab friends that the saliva of a camel is host to a certain rather awful social disease. On the basis that even a 0.1 per cent likelihood of truth might lie behind this rumour, and on the dreadful images which sprang from it ("You're not going to believe this, darling, but . . ."), I had hitherto steered well clear of all camels encountered in Baluchistan

"Aroused camels are dangerous. I was told that a camelman in a nearby village had tried to intervene in the amorous affairs of one of his beasts a few weeks before, only to be killed during his noble efforts at population control. The camel had taken him by the neck, hurled him through the air, and to add insult to an already fatal injury, trodden on his head." □



Preparing a camel for loading on a truck.

haviour in central Australia. From their many hours of observations, much will

undoubtedly be learned about the likely impact of camels on the environment.

It seems, from what is known so far, that among the plethora of feral animals that are the scourge of Australia, including pigs, horses, dogs, cats, foxes, donkeys, buffalo, rabbits, introduced birds and disgusting cane

toads, there are plenty of candidates higher up the list for eradication programs than the camel. Indeed, compared with the freeloaders and destroyers on this undistinguished list, it could be said that camels, more than any other feral animals, have contributed more to Australia than they have taken away. □

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Satellite Tracking

Gordon Grigg's interest in camels was stimulated originally by seeing them during aerial surveys of kangaroo populations. Since May 1986 he, with colleagues at the University of Sydney, has been following the movements of two female camels south-west of Alice Springs—the first use of satellites for tracking wildlife in Australia. This research has been made possible by a grant from the Australian Research Grants Scheme. The advantages of satellite telemetry are that, once the radio collars are attached, the animals are followed via a computer linkup, no matter where they go, and without the need to spend tedious and time-consuming months in the field. So far the results

from the camels refute what has become the conventional wisdom that camels move long distances each day as they forage. The two female camels under study mostly travel only short distances daily, if at all, moving to a new area for a further period. It is hoped that data will be accumulated until the end of 1987.

The project is short of funds for the continued purchase of the satellite data. Tax deductible donations (minimum \$20) would be most welcome and Gordon will put your name on the mailing list for the periodic *Camelletters* that circulate news of the project and the camels' wanderings. Cheques should be made payable to Wildlife Research Unit and sent to Zoology Building, University of Sydney, NSW, 2006. □

LETTERS Whinges and Cringes and Habitat Fringes

Creationist Cancels

I refer to an article written by Robyn Williams entitled "Worrying About Creation 'Science'" (ANH, vol. 22, no. 3, p. 132). This author, who is apparently the Australian Museum Trust President, spends the entire article denigrating fellow scientists who hold to a different view to himself. He uses no scientific evidence to support the theory of evolution but finds it impossible to tolerate the thought that others may hold to the theory of special creation. I find such a position intolerable and such bigoted articles deserve only one response. Please cancel my subscription.

—Chris B. Chapman
Harvey, WA

I cannot imagine how Mr Chapman managed to infer that I denigrate "fellow scientists who hold to a different view" on creationism. I know of no scientists of any repute who believe in creationist doctrine despite my 15 years as a science journalist, working throughout the world.

My article quoted research by Prof. Rhondda Jones of James Cook University showing that an alarming number of students in Australian universities have had their thinking "muddled" by being taught creationism at some time when at school. A recent Gallup poll states that 44 per cent of the American population agrees with the statement: 'God created man pretty much in his present form at one time within the last ten thousand years' (quoted in The Wisdom of Science by Prof. Hanbury Brown, Cambridge University Press, 1986).

There is, as I tried to imply in the article, a real crisis in science education, here and in the United States. It is caused in part by a religious-

political movement that pays little heed to the standards of evidence and scepticism that are displayed by science at its best.

My article was not an attempt to argue the case for evolution. But I did say that biologists dispute only its mechanism. They do not deny that it happened.

—Robyn Williams

Applause for Archer

I would like to congratulate you on the last issue of ANH (vol. 22, no. 4). The articles were most interesting and the photographs magnificent. Especially, I commend the article by Michael Archer on creationism and the editorial staff for publishing it.

—Dr L.G. Cartwright
University of Sydney

More on Toads

Public interest in the introduced Cane Toad remains high. Evidence to hand suggests that the Townsville populations have declined and that Cane Toads are in poor condition. This needs to be confirmed using capture-recapture techniques, and this is currently being done. If the populations have declined we need to know what has caused it. In recent newspaper articles it has been suggested that a decline in Cane Toads in the Townsville area can be attributed to a more efficient shire council, which has cleared up the area, reducing the amount of food available for the toads. This sugges-

tion, however, seems too simplified, given the biological data on Cane Toads already accumulated.

Dr Ross Alford of James Cook University, for example, has recently found that some native tadpole populations around Townsville may carry a disease that kills Cane Toad tadpoles. How common this is and whether the disease exists in the Gulf is as yet unknown but research is underway. We also need to be able to simulate Cane Toad populations in the computer in order to determine what effects, if any, a disease may be having on Cane Toads (be the disease native, or a South American one that may have biocontrol potential).

Many factors also need investigation, for example climatic factors, parasites, shelter availability etc. It is not a simple problem but we may be making progress.

The Council of Nature Conservation Ministers' (CONCOM) Cane Toad program has been underway for nearly 12 months and has made significant progress, its primary goal being to provide a basis for the biological control of Cane Toads. This can be achieved only after we have thoroughly investigated the Cane Toad's impact on the native fauna; whether Townsville populations have actually declined and, if so, why; and what diseases and parasites the Cane Toads have. The work must be thorough in order to understand what the Cane Toad is doing to the fauna and, if necessary, to know how to

control its populations and spread.

—Dr W.J. Freeland
Conservation Commission of
the Northern Territory

Economic (not Cultural) Cringe

Like Tim Low in his article, *Raspberries, blackberries and the cultural cringe* (ANH vol. 22, no. 2), I grew up in an era when nearly all the nature books and films were English or American imports. It was most frustrating and extended to other areas such as astronomy, for as children we had to rely on what the libraries stocked. Libraries, for us, were few and far between and in that post-depression era it was easier and cheaper for librarians to stock the nature section with overseas remainders.

It's true that many of the earlier settlers were ignorant of the ways of nature but they had little education and even less time to improve their knowledge of nature by observation. However I would challenge the concept that my generation suffered from a cultural cringe. The problem was one of economics. There was not a sufficient market or efficient distribution network to support Australian nature books.

One of the books that fired my imagination in those far off days was called *Little Savage*. It was a delightful story, as I remember it, of children who went through the adventures of living out of doors 'Red Indian'-style. It was the sort of thing children anywhere would love to emulate. In my childish fancies I hoped that one day a similar book would be written about Australia. I still believe that such a book could be written and I think Tim Low would be the person to do it.

—P.R. Smith
Blackburn, Vic.



DAVID MAITLAND



ROBYN WILLIAMS

What's Natural About Natural History?

"The survival of our wildlife is a matter of grave concern to all of us in Africa. These wild creatures amid the wild places they inhabit are not only important as a source of wonder and inspiration but are an integral part of our natural resources and of our future livelihood and well-being."

Julius Nyerere, President of Tanzania 1964-1985

The Arusha Declaration, Tanganyika, Sept. 1961

"I could be one of the last generation that is lucky enough to see the rhinoceros or the tiger in their natural environment", said my American friend, who is appalled at the prospect. She is a biologist and fully aware of the death toll recorded each year for the bigger beasts. "We can stick a few of them in zoos so our kids will see the relics, but how do you explain to them that we

allowed treasures like that to become extinct and on such a scale?"

But, you might say: "That's the way with nature. Catastrophes occur, climates change and species go. A new balance replaces the old." In the last century, however, more species have disappeared than ever before. Peter Raven, the Director of the Missouri Botanical Garden and a noted conservationist, warns that the richest ecosystems on Earth—the tropical rainforests—will soon be gone unless their rate of destruction is halted. The nature we observe today is rarely unaltered by humans. And so we see a distortion—balances are altered and it is often difficult to discern the 'pre-human' scene.

Consider the kangaroos. Only in one or two places in the remote parts of Western Australia do they still live as they did before European farmers opened up the bush, providing constant water supplies where once there was none. Three of the large kangaroo species, the Eastern and Western Greys and the big Red, increased enormously in number. Their reproductive cycles, very much governed by the availability of food and water, were also altered drastically. We now think of 'roos as pests and have kill quotas of three million a year. Not many Australians know of the other 46 species of macropods—the smaller ones, some endangered. Having distorted nature we often see ugliness. The next stage is to reject it.

Consider a tropical island in the South Pacific. The forest may be lush and dense, but the soil is invariably poor and thin. The richness is in the canopy where birds, insects and small plant life abound, nurtured by the immense green leafiness all about. But, when you knock down the trees to expose the fragile soil to wind and sun, the spectacle is as squalid as before it was spectacular. Nothing is quite as bleak as an island stripped bare, as any traveller flying above will testify.

These are examples of obvious effects of recent human intervention that make any scientific observation of a 'natural state' almost impossible. Less visible are the untold thousands of micro-organisms and small plants and animals that will become extinct, some-


times without our even knowing, as civilisation spreads.

But isn't destruction itself a 'natural' process? After all, here is Nature responding to the chainsaw, the bulldozer or whatever. We are part of the natural process so what we do is as much natural as the celebrated meteorite that is supposed to have crashed to Earth 65 million years ago, sending up vast quantities of dust to shut out the sun and so, apparently, cause thousands of organisms, including dinosaurs, to become extinct.

Well, I must admit that I am certainly very fond of the English countryside, which is, almost entirely, a human invention. No more forests brimming with bears and wolves; instead hedgerows and gentle fields stretching like a patchwork to the horizon, with little stone walls built centuries ago, still standing quietly. There you can perceive the history of people blending with the landscape—acts that were done, in the main, without the knowledge that they could be irrevocable. People often improved on nature or, at least, lived lightly on the land. In fact, until very recently, we struggled to maintain a patch in the wilderness. Now, for the first time, we can contemplate a total elimination of that wilderness.

From a scientific point of view, it is of concern because so much of the remaining natural heritage is unrecorded, unrecognised. Even large mammals in Australia have not been studied properly; there are enormous gaps. To be sanguine about the present state of things is like saying you can "know all there is to know about the natural world by examining the plants and animals in your back garden". Life appears to have flourished in only one small part of our solar system, so it would be an act of hooliganism to allow most of this treasure-trove to die.

From a personal point of view it is of concern because people in most societies clearly enjoy unspoiled countryside. A lyrebird spotted in the woods is worth a dozen trapped in a cage. Yet people don't appreciate how vulnerable nature can be. Remember those traces of DDT (a pesticide now banned) discovered in Antarctica? The reach of human messing is far greater than you first suspect. What would the world be like if everywhere you looked you saw nothing but your own face? □




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POSTER

Moths on Their Native Food Plants

Painting by Helena Scott, c. 1860

Small moths are very difficult to illustrate in all their intricate detail. However, Helena Scott has succeeded admirably as most of those on the plate are readily identifiable even though none has a wingspan greater than four centimetres.

Identifying many of the moths on this plate is easy because of the accuracy of the details of the moths themselves, their foodplants, larvae and the small structural diagrams. The larvae of geometrid moths are distinctive. They have two prominent pairs of rear prolegs, such as portrayed in the top left illustration of *Corula geometroides* Walker, one of three geometrids on the plate. Here it rests on Native Cherry (*Exocarpos cupressiformis*). The second geometrid, one of the delicate emerald moths, *Chlorocoma cadmaria* (Guenée), is depicted in the centre on Native Currant (*Leptomeria* sp.), and the other, one of the few that cannot be identified to species, is shown centre right. Scott's plate, even now, constitutes the first record of the biology of these first two geometrid species, although being published more than 120 years after preparation.

Unlike *Corula*, which has a limited distribution from the Hunter River to just south of Sydney, the pyralid *Hymenia recurvalis* (Fabricius), shown in the upper centre on New Zealand Spinach (*Tetragonia tetragonioides*), is almost cosmopolitan in warm climates. It is a well-known pest of beet and other crops in many countries.

Helena Scott has shown with discerning accuracy a most peculiar habit of the larva of the nolid moth *Uraba lugens* Walker—that of stacking the cast larval head capsules from previous moults above its head. The larva shown here on *Eucalyptus* sp. tips at the lower left, is a serious defoliator of eucalypts across southern Australia, and has the ability to cause itchy skin rashes if handled by humans.

The moth beside *Uraba*, shown on *Elaeodendron australe*, is a tortricid of



the subfamily Olethreutinae, characterised by the single band of scales per segment indicated on the diagram of the antenna. This group is large with so many similar species that the one illustrated is not identifiable. The brilliantly coloured tortricid at the lower right is *Aristocosma chrysohilana* (Walker) whose larvae feed on *Elaeocarpus*, including Blueberry Ash, from Stradbroke Island to Batemans Bay.

The names I have used all differ from those on the plate. To be used,

a scientific name must be the oldest published name. Despite the fact that the plate was prepared before 1864 and possibly before 1851, it was never published and the names A.W. Scott coined have never been used. Most of the moths illustrated were described later by other authors but few subsequent artists characterised the species as clearly as Helena Scott and certainly none so beautifully. □

—Ted Edwards
CSIRO, Division of Entomology

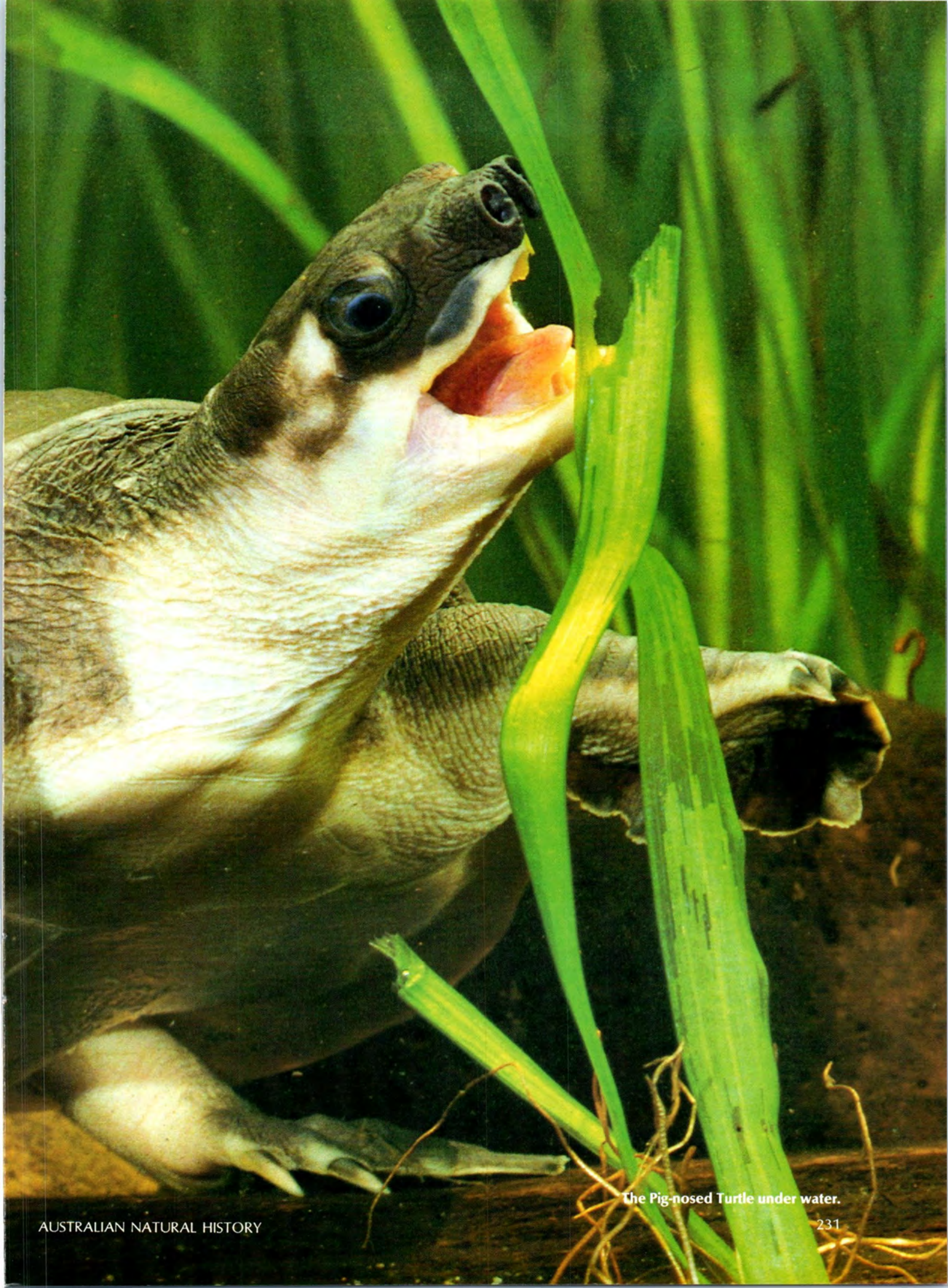
The Pig-nosed Turtle Warradjan

By Arthur Georges
CCNT and Canberra CAE

Warradjan is an Aboriginal name given to the Pig-nosed Turtle (*Carettochelys insculpta*), found only in the freshwater and estuarine reaches of rivers of southern New Guinea and northern Australia. This unusual turtle is the sole surviving member of a once widespread group, represented as Tertiary fossils from Europe, North America and southern Asia.

Anyone observing the species for the first time will be struck by how different it is from other Australian freshwater turtles. It is a large animal over half a metre long and weighing over 20 kilograms. The head is withdrawn straight back into the shell (the neck flexes in a vertical plane) rather than swung to the side as in all other Australian freshwater turtles. It has flippers superficially resembling those of sea turtles rather than the limbs of freshwater species, a feature which led ear-

JOHN CANN



The Pig-nosed Turtle under water.

ly biologists to mistakenly consider the species to be a link between the sea turtles and freshwater river tortoises. The species totally lacks the horny scutes that overlie the bony shell of most turtles. Instead the shell is covered with skin—soft and cream-coloured on the undersurface; thin, taut and greyish brown above. The nostrils open at the end of a prominent fleshy proboscis through which the turtle inhales not only air at the surface but also water when submerged. Passing water through the nostrils may serve to enhance smell but the regular way in which it is done suggests some other function. Perhaps the cone-shaped papillae at the rear of the mouth, first noticed in 1963 by Thomas Schultze-Westrum, serve a respiratory function, or they may instead serve as salt-secreting organs during forays into saline waters.

History

Carettochelys insculpta was first described in 1886 by Dr E.P. Ramsay from a single specimen in the collection of the Australian Museum. It was one of two turtles collected by explorers Walter Froggat and Jas. H. Shaw on an expedition to New Guinea with the Geographical Society of Australasia. As Froggat later wrote to Edgar Waite (South Australian Museum) in 1905:

"Six of us took the whale boat up the last hundred miles [of the Fly River] after the 'Bonito' struck the gravel, and as we towed the boat along the two turtles ran off the sand banks into shallow water and were caught. We ate the contents of both: a large number of eggs were found inside them. It was evidently breeding time as some of the sand banks were covered with their tracks."

The turtles no doubt tasted good at the time but the meal was to result in a prolonged disagreement among taxonomists over the affinities of this new and unusual species. Ramsay, in his initial description, grouped the species with the soft-shelled turtles (family Trionychidae) of the northern continents. Only three years later, George Boulenger (British Museum of Natural History) placed it in its own family, the Carettochelydidae, and included it among the suborder of side-necked turtles, the Pleurodira. At the time, only side-necked turtles were known from Australasia and this appears to have been Boulenger's prime reason for the move. G. Baur, working from photographs, was vehemently opposed to grouping *Carettochelys* with the side-necked turtles, and called upon Ram-



IAN MORRIS

It is obvious why this animal is called the Pig-nosed Turtle.

say to release details of the vertebrae in the neck to "show at once the affinities of this peculiar genus". "Alas!", responded Ramsay, "there were no cervical vertebrae to examine; the animal had served the explorer[s] for food, and the whole of the bones, except for the skull had been cut away". The matter remained one of considerable debate until 1905 when Edgar Waite received a more complete specimen from the Island of Kiwai in New Guinea. He showed conclusively that *Carettochelys* is not a side-necked turtle.

The debate over what living form is the closest living relative of the Pig-nosed Turtle continued sporadically until the present day. Current wisdom has it that the closest living relatives are among the soft-shelled turtles, as Ramsay had originally claimed, although the species is sufficiently distinct to warrant its own family, the Carettochelydidae.

Life History

Given that the regions occupied by Pig-nosed Turtles are remote, a surprising amount of information, albeit general, is known about their life history. Although a fast swimmer, the Pig-nosed Turtle is essentially a bottom-dwelling species, at least in the dry season, spending much of its time in and around logs and undercut banks and feeding mainly at night. It has broad habitat requirements and lives both in the permanent lentic mainstream and floodplain billabongs of Kakadu National Park and in the continuously flowing

waters of the Daly River system. There are no substantiated reports of the species occupying estuarine habitats in Australia, but it certainly does so in New Guinea where they even nest on the sandy shores of river deltas and on coastal beaches.

Pig-nosed Turtles are opportunistic omnivores. Figs, pandanus fruits, flowers, leaves and seeds that fall into the water from overhanging vegetation, and aquatic plants such as ribbon weed, are eaten. Animal foods recorded from among their faeces include water snails, freshwater mussels, aquatic insect larvae and nymphs, windblown insects and carrion. A hair ball was taken from the stomach of one specimen in Kakadu National Park.

Until recently, data on the reproduction of Pig-nosed Turtles were few, based largely on observations incidental to broader studies in Papua New Guinea. In fact when Dr Harold Cogger (Australian Museum) first reported in 1970 that the species occurred in Australia, he was not certain whether the populations were self-sustaining or whether they merely represented a non-breeding outlier of the New Guinea populations. However it is now known that each year in northern Australia, between late August and mid November, females of the species leave the water to lay one, two or perhaps even three clutches of eggs. They choose banks of clean fine sand adjacent to water in which to nest, and construct an egg chamber about 22 centimetres deep



An uncovered nest chamber of the Pig-nosed Turtle in which the eggs have been numbered, measured and replaced.

and between 30 centimetres and three metres above water. In the chamber they deposit between four and 19 round, hard-shelled eggs ranging from 31 to 42 millimetres in diameter—very much like ping-pong balls in size and appearance. After covering the nest the female returns to the water and the eggs begin development which, in natural nests, lasts for about 70 days. It is at this stage in their life history that the turtles are most vulnerable, as the adults take no further measures to protect their eggs or the hatchlings that emerge from them. Many nests fall prey to goannas and some of the lower nests die when flooded by early wet-season rains.

After 65 to 70 days of incubation, the eggs are quite capable of hatching, but instead they enter a form of torpor—their metabolic rate and demand for oxygen drops precipitously, and they wait. Further experiments by Grahame Webb (Conservation Commission of the Northern Territory) and his colleagues have shown that immersion of the eggs in water is sufficient to arouse the torpid hatchlings they contain, and subsequent experiments in the field have shown that not only flooding but also torrential rain can stimulate hatching. Clearly the young turtles delay hatching until the first heavy rains of the wet season flood the nests or saturate the sands that surround them. Presumably the hatchlings gain some benefit from this strategy, hatching into water where there may have been no water before, or into turbid water that may have been clear before. The first floods may enable dispersal of potential predators previously concentrated in the contracted waterbodies and may open new areas into which the hatchlings can disperse to feed and seek shelter.

During incubation, the embryos

must withstand high temperatures (up to 38°C) and considerable daily fluctuations in temperature. Although not even the hottest of the 38 nests examined by me in late 1986 (as yet unpublished data) seemed to suffer undue mortalities, temperature does exert a more subtle influence on their early lives—their sex depends upon the temperature at which they are incubated. Nobody as yet has an entirely satisfactory explanation for this phenomenon. In the field, cool shaded nests produce only males, hot exposed nests produce only females, and nests with an average core temperature of around 31.6°C produce a mixture of sexes. Pig-nosed Turtles are not unique in this, as the phenomenon is almost universal among turtles in seven of the eight families so far studied worldwide. However, it is the only freshwater turtle in Australia with this trait, all the rest belonging to the family Chelidae in which sex determination appears to be independent of temperature. The implications of temperature-dependent sex determination for management of Pig-nosed Turtles may be considerable, because some management programs, where sea turtle eggs have been incubated in shaded artificial nests, have resulted in the release of thousands of young male turtles, contributing little to the species recovery.

Nothing at all is known of the lives of hatchlings once they enter the water. Where do they go in the wet season and what predators must they avoid? How fast do they grow and what size must they reach before they breed themselves? How do they fare in competition with other turtles—the Northern Snapper (*Euseya dentata*), the Yellow-faced Turtle (*Emydura victoriae*) and the Red-faced Turtle (*Emydura australis*)—with which they share their environment? These are all questions for future study.

Value to Indigenous Peoples

It has long been known that the Pig-nosed Turtle is well regarded by indigenous people within its range. In 1898, George Boulenger described a dancing stick from the Fly River region that was adorned with the skulls of the species, and the turtles are referred to in folklore. One novel story told by the chief of Mabadumu on Kiwai Island around the turn of the century was recently published by Dr Peter Pritchard (1979) in his book *Encyclopedia of Turtles*:

“The first time a Minowa [Pig-nosed Turtle] was seen was a long time ago, on a mud bank at Demeramuba. A man

and his wife were going past on their way to their garden, when they saw two Minowas lying side by side in the mud [this turtle is always said to lie on the mud when copulating]. The woman said ‘Could we not do this thing that the strange turtle does?’. The man replied ‘I do not know anything of it’. The woman persisted, and on going to their garden they laid side by side, as they had seen the turtles, and after a time, the act of coition took place, and in due course the woman conceived and a child was born to them”.

At the time, the Kiwai villagers would not kill the turtles because they believed that to do so would endanger their chances of becoming fathers, or that their existing sons would be rendered impotent.

The attitude of the Kiwai people today has probably changed. Certainly elsewhere within its Papuan range, Pig-nosed Turtles are favoured by villagers for food and they are important in the subsistence economies of many communities. In the breeding season, villagers collect female turtles and their eggs when they come to shore to nest, or they locate nests by systematically prodding sand banks with a stick or spear. In some areas, pit-traps are checked each day for nesting turtles that have fallen into them on the previous night. At certain times of the year, many adult turtles and thousands of eggs pass through the Kikori markets alone. Out of season, the turtles are speared or caught by hand from boats in shallow water and swamps, or are caught on lines baited with crab or deshelled mussels and in basket traps.

In northern Australia, turtles are eaten regularly by Aborigines and Pig-nosed Turtles are favoured by some for their size and flavour. Carla Ngalyorrin of Nourlangie, Northern Territory, recalls that men used to climb trees on the banks of a billabong in the early morning during the dry season when the water is clear. When they saw Warradjan near the surface they would pierce the front flipper with a pronged spear. Other reports indicate that Warradjan could be hunted by diving on top of them from the bank or by waiting quietly in the water while others herded the turtles in. Today, however, they are more often caught on hand lines baited with wallaby or buffalo meat.

Paintings of the Warradjan are well represented in the rock art of Kakadu National Park and adjacent Arnhem Land, a measure of the importance placed on the turtles as food by Aborigines. Notable examples of this art are at Nourlangie Rock (blue paintings),

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ARTHUR GEORGES

An Aboriginal painting of the Warradjan at Little Nourlangie Rock in Kakadu National Park. Paintings such as this appear throughout Arnhem Land, but this particular one is well known as one of the 'blue paintings', touched up with Reckitts Blue by Aborigines in the early 1960s.

Deaf Adder Creek and on the Arnhem Plateau in the Mann River catchment. Some of these paintings are estimated to be more than 7,000 years old, indicating that the Pig-nosed Turtle is not a recent arrival but a long-term resident of northern Australia. Aboriginal legend has it that Warradjan and Manbirri, the Green Sea Turtle (*Chelonia mydas*), are sisters (Manbirri being the younger). A long time ago when the salt water was "going away", Manbirri decided to go with the salt water while Warradjan decided to stay in the fresh water with Naderrwo (the Northern Snapper). The salt water went away a long time ago indeed, between 7,000 and 20,000 years ago during the last ice age.

Management

Assessing the conservation status and the need for a management plan for the Pig-nosed Turtle is seriously hampered by lack of demographic information. It was once considered to be one of the rarest turtles in the world, but whether this reputation reflects only its remote distribution or also low population densities is unknown. It is considered relatively common within its restricted range by many who know the animal in the field, but this needs to be confirmed by research specifically directed at assessing population numbers.

Stereotyped nesting habits render Pig-nosed Turtles (like sea turtles) extremely susceptible to over-exploitation. In Papua New Guinea, populations are reported to have been seriously depleted in the last 20 years in regions where the adults and eggs are eaten, such as the Kikori River Dis-

trict. This exploitation has no doubt occurred over many generations with little impact on turtle populations, but it has been exacerbated in recent times by the introduction of modern technology, principally outboard motors, and because, since clan warfare has ceased, people have moved from the hinterland to more convenient positions along the river banks.

The impact of Aboriginal harvesting of Pig-nosed Turtles in Australia is unknown. Exposure to western culture and technology has changed Aboriginal practices. Aborigines now primarily secure Pig-nosed Turtles with baited hooks on lines, which may be more effective than traditional methods. Refrigeration and improved transport encourage removal of more turtles than are required for immediate use by the local community. Turtles from the Daly River Mission area are caught and transported to Darwin some 220 kilometres away for the benefit of friends and relatives. The extent of this sort of trade in northern Australia is not known.

Both legal fishing with baited lines and illegal fishing with 'square hooks' (gill nets) can be expected to exert some pressure on Pig-nosed Turtle populations. Fishermen can be brutal when a 'nuisance' turtle is caught on a line. In an attempt to retrieve a 15-cent hook and sinker, many will readily destroy the life of a 60-year-old turtle. Fortunately, Pig-nosed Turtles are unlikely to be caught on lures designed to catch Barramundi, central to the sports fishing industry of the north, and they are not caught in large numbers by commercial fisheries.

In Australia, Pig-nosed Turtle populations have been sheltered from potential threats by their isolation, but with future development this may rapidly change. Vast tracts of land in the Daly River catchment are being cleared, in places down to the waterline. Such clearing, which has occurred in many other parts of Australia, will result in long-term degradation of the river and perhaps adversely affect the Pig-nosed Turtle and other organisms upon which it feeds.

Several sources used to construct this article have called for studies of the distribution, population structure and dynamics, habitat requirements and levels of exploitation of Pig-nosed Turtles to be given a high priority in conservation funding. Such information is required for an objective assessment of the species' rarity, and to determine if any of its populations are endangered or in need of remedial management programs. □

photoart

OUTBACK SENTINELS

MARIANNE PORTENERS

FREELANCE PHOTOGRAPHER

Marianne's interest in photography developed from a long-standing love of the Australian bush. She completed a B.Sc. in zoology and botany at the University of Sydney, which gave her the opportunity to visit many unusual places on field trips. This sparked off a desire to record it all on film. An interest in arid regions was developed during several trips to north-western New South Wales. A number of zoological and botanical projects, including a study on the Mallee Fowl in central New South Wales and sea turtle research at Mon Repos, Queensland, have taken up much of Marianne's time.

Marianne's main area of interest is photographing wildlife and national parks. Her endless inspiration is found wherever she travels, be it small parkland close to home in Sydney, or well-known areas such as the Flinders Ranges and Wilsons Promontory. Her most recent trip took her to the Northern Territory for the first time and her next aim is a more in-depth exploration of the parks of the Northern Territory and tropical Queensland.

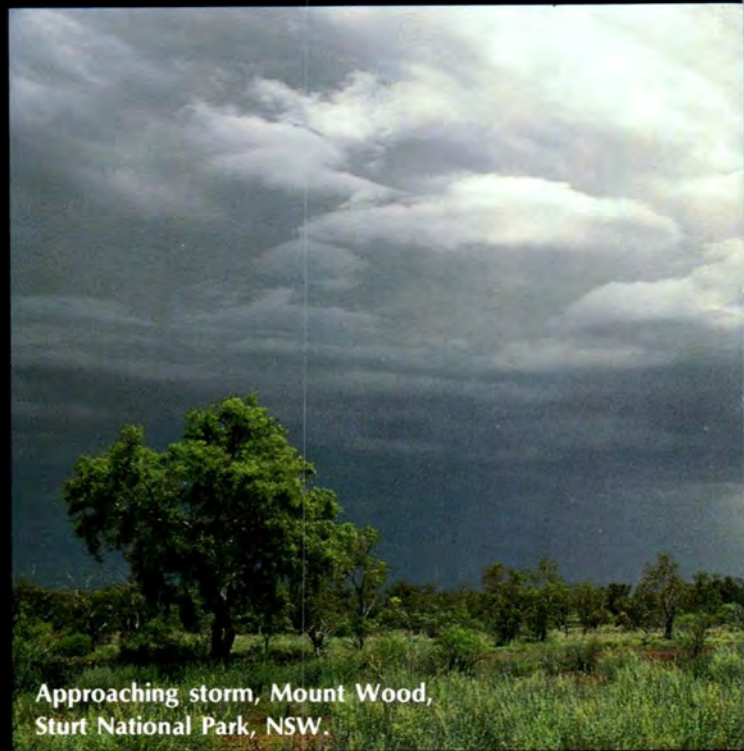
"I find photography to be an absorbing creative outlet, which also satisfies my wanderlust. I will return to a particular location time and time again to capture it in all its moods. Equipment is kept light and compact enough to fit into a comfortable back-pack. I mainly use Kodachrome 64 film for its high quality", says Marianne.

"My favourite times for photography are early morning and late afternoon when the low sun renders the landscape in crisp saturated colours. I particularly enjoy travelling the outback (heat permitting!) in early summer to capture the dramatic storms that occur at that time." □



Coolabahs, Lake Cawndilla, Kinchega National Park, NSW.

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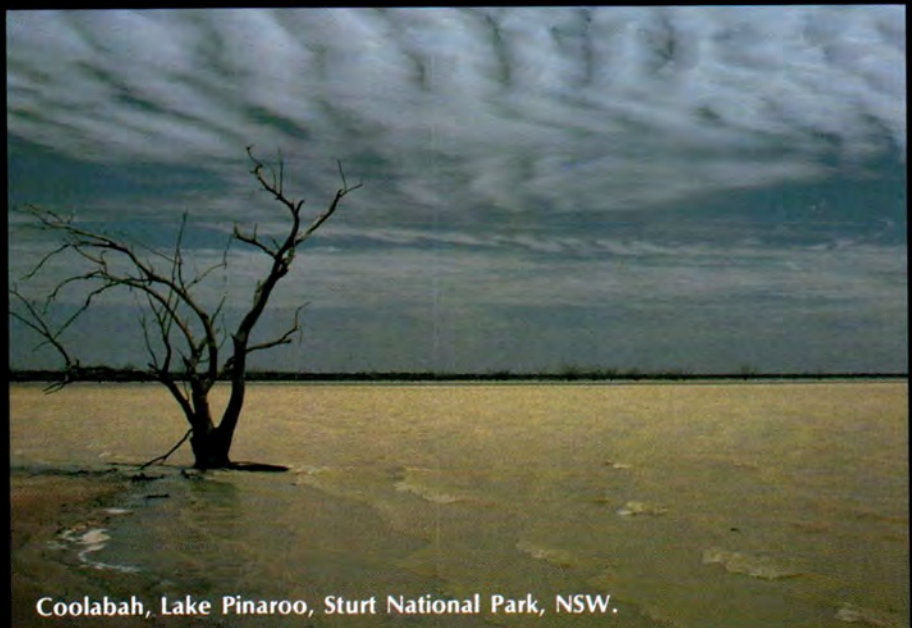
Approaching storm, Mount Wood,
Sturt National Park, NSW.



Coolabahs, Fort Grey, Sturt National Park, NSW.



Billabong reflections, Mootwingee National Park, NSW.



Coolabah, Lake Pinaroo, Sturt National Park, NSW.



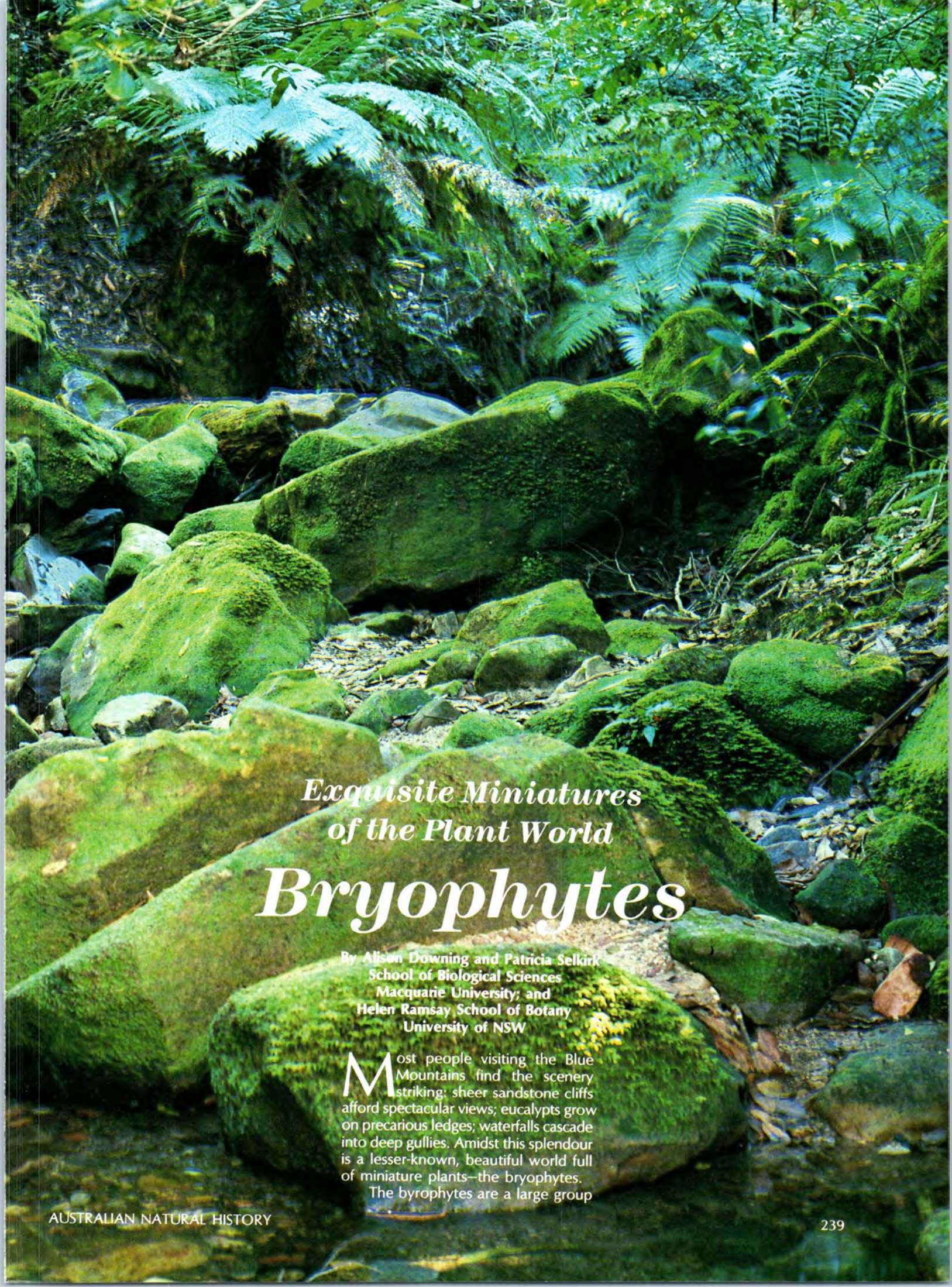
Dicranoloma sp. (a moss) is commonly found in tall forests. Jaunty capsules set at rakish angles protect capsules during their development. The capsule at the right has provided a meal for some small hungry forest dweller.



Symphyogyna podophylla, a thallose liverwort, covers rock and soil surfaces in moist valleys. Young capsules can be seen developing on stout stalks.



A Coachwood seedling has become established amongst the mosses on this rock.



*Exquisite Miniatures
of the Plant World*

Bryophytes

By Alison Downing and Patricia Selkirk
School of Biological Sciences
Macquarie University; and
Helen Ramsay School of Botany
University of NSW

Most people visiting the Blue Mountains find the scenery striking; sheer sandstone cliffs afford spectacular views; eucalypts grow on precarious ledges; waterfalls cascade into deep gullies. Amidst this splendour is a lesser-known, beautiful world full of miniature plants—the bryophytes. The bryophytes are a large group

of small land plants, comprising mostly mosses and liverworts. Indeed they are often overlooked because of their size. There are about 23,000 species of bryophytes, all fairly simple in structure. They colonise fallen logs, tree trunks, cliffs and rocks, and are important pioneers on bare soil. Typically they grow in moist or humid places but some are common even in cities where they manage to find a toe-hold in the hostile environments of brick paving, damp concrete and stone walls. Some can also survive in harsh conditions such as the arid interior of Australia and in parts of Antarctica.

Mosses have stems that can be upright or creeping and their leaves are characterised by a midrib. When reproducing, they have a distinct capsule on a rigid stalk. The capsule is green when young, and has a lid (operculum), which falls off at maturity. Single-celled spores are then released through a toothed fringe (peristome) that opens and closes with changes in atmospheric humidity. The capsule browns after releasing all its spores. Some mosses may have capsules at any time of the year but they are most common in winter and spring.

There are two main types of liverworts: fleshy and leafy. Flat, fleshy (thallose) liverworts often grow in greenhouses and wet places. Leafy liverworts are often mistaken for mosses but their delicate leaves do not have midribs, and are usually arranged in three rows, two on each side of the stem, and one underneath. The capsule of a liverwort is usually a small, black sphere on a translucent, fragile stalk, quite different from the wiry, rigid stalk of moss capsules. In most species the capsule splits in four to reveal a mass of spores mixed with special long cells called elaters. The walls of the elaters have a spiral thickening, which causes the elater to twist erratically with changes in atmospheric humidity. As a result, the spores are dispersed gradually into the wind.

Both mosses and liverworts have a great capacity to produce new plants, not only from spores but also from fragments of leaves or from gemmae—small structures that easily break away from the parent plant and sprout readily.

Despite their differences in appearance, mosses and liverworts share a number of features that distinguish them from other land plants. Bryophytes are attached to the soil or rock surfaces on which they grow by thread-like rhizoids rather than by the roots possessed by most other land plants. Rhizoids are only a single cell in di-

ameter and resemble root hairs. Although serving as effective anchorage, they do not have an internal conducting function. Unlike other land plants, which have well-developed internal conducting systems, most bryophytes rely on external moisture, absorbed over a large surface area. They may trap water between leaf and stem, between overlapping leaves, or between the closely packed stems of a moss clump.

The Blue Mountains to the west of Sydney reveal bryophytes in their element—thriving and luxuriant. In fact, a third of the moss species that occur in New South Wales are found in the Blue Mountains. Most of them are in the sheltered gullies but some are found in not so moist and shaded places.



Stems of *Papillaria* sp. festoon branches of trees and shrubs in wet forest.

On ridge tops in the Blue Mountains, the sandy soil is mostly shallow with little water-holding ability. It overlies porous sandstone rock and the vegetation is exposed to wind and sun. The open woodland vegetation includes gnarled eucalypts (such as Black Ash, *Eucalyptus sieberi* and Scribbly Gum, *E. sclerophylla*) and tough shrubs with leathery leaves (such as needlebush, *Hakea* spp. and Mountain Devil, *Lambertia formosa*). If you look carefully on ridge tops in the area, you will find a surprising number of different bryophyte species despite the apparently harsh conditions. They can be found on shaded sides of rocks and fallen logs, in soil pockets in rock crevices, on roadside banks, in seepage areas and sandstone depressions that might trap water for a little longer than the sandy soil. Mosses are more successful than liverworts in colonising these areas. Sometimes bryophytes may appear to be dead, crisped and curled, but don't be fooled. A short shower of rain will uncurl the leaves within seconds and the plants become green, sometimes only to dry and curl up again hours later under a hot sun and drying winds—they are efficient resurrection plants.

Below the ridges, the significant increase in size and number of trees and shrubs in the valleys is accompanied by changes in the type and variety of bryo-

phytes. The tree canopy becomes denser and, together with the overshadowing ridges, provides more shade to the valleys, minimising desiccation. Valley temperatures are less extreme and humidity higher than that encountered on the ridge tops. Bryophytes are abundant in the dark coolness of the Sassafras (*Doryphora sassafras*) and Coachwood (*Ceratopetalum apetalum*) rainforest in the gullies. Here they thrive in low light levels, on moist soil, tree trunks, branches, fallen logs, rough trunks of tree ferns, and wet rocks, by creeks and around waterfalls. The variety and size of bryophytes increase in such situations.

At Mts Wilson, Irvine and Tomah, rich, deep volcanic soil caps the sandstone ridges. The volcanic soil supports a denser rainforest vegetation, which in turn provides an environment rich in bryophytes. Many mosses and liverworts, which usually grow in protected deep gullies, thrive in rainforests on these volcanic outcrops. Particularly striking here are the mossy curtains of *Papillaria* spp. festooning the branches of shrubs and Coachwood trees.

Both mosses and liverworts often colonise bare rock surfaces, soil and burnt ground, where later seed plants may grow. Common colonisers of roadside banks and disturbed soil in the Blue Mountains are the mosses *Pogonatum subulatum* and *Dawsonia superba*. *Dawsonia superba* is a very large moss (looking a bit like a small pine tree seedling) commonly 30–40 centimetres tall and sometimes reaching 60 centimetres or more.

Epiphytic bryophytes (on tree bases, trunks and branches in wet forests) are an important home for insect larvae and many other types of tiny animals. They represent microforests, providing shelter and in some cases food. Some fascinating interactions between bryophytes and insects are known from overseas studies. For instance, some New Guinea rainforest weevils live disguised as clumps of bryophytes, with mosses and liverworts growing on their backs. The bryophytes serve as camouflage but may also make the insects distasteful to predators. Interactions between Australian bryophytes and the tiny animals that live amongst them await description.

Bryophytes, although small in stature, are important members of a plant community. Their delicate beauty requires the magnification of a x10 hand lens or a camera macro lens for full appreciation. Their presence in profusion adds to the delights of a visit to the Blue Mountains. □

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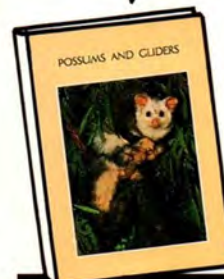
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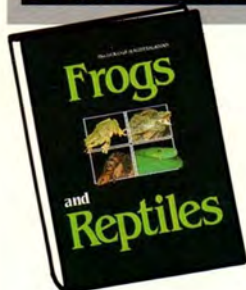
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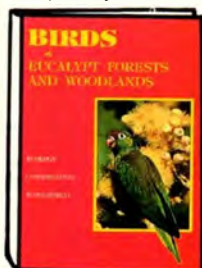
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