

# The small marsupials

**'Their generation or procreation is Very Miraculous, Yea, worthy to note; under the belly the females have a pouch ...'**

After being shipwrecked off the coast of Western Australia, the Dutch merchant François Pelsaert and some of his companions encountered 'large numbers of a species of cats, which are very strange creatures'. Just how strange, Pelsaert recorded in his journal, giving the world the first written description of an Australian marsupial. The animal was the tammar wallaby, the year 1629.

More than 350 years later, the pouched mammals are still far less thoroughly known to zoologists than the group to which we, our pets and herds, and all the native mammals of the Old World belong: the eutherians.

Kangaroos have come under detailed scrutiny, but we still have a great deal to learn about the small marsupials and increasing reason to study them, for one of the earliest observations was that many species have come off second-best in the clash with European man. The marsupials of the inland plains have suffered most: of 21 species present in Pelsaert's time, nine have become extinct and all but three are rare. Those three are kangaroos.

Australia holds a special place in the history of mammals. It is a marsupial island in the sea of eutherian evolution. To understand how this came about we must turn back the clock 100 million years to the middle of the Cretaceous period to see the shared ancestors of marsupials and eutherians, and then wind time forward some 30 million years and watch the gradual evolution of these two great mammal groups and the tussle between them for possession of the continents — a tussle that the eutherians eventually won.

The marsupials survived on only two land masses, into which few eutherians had penetrated: South America and Australasia. In South America marsupial evolution was from the first cramped by competition from eutherian herbivores, and much later set back by eutherians invading across the new land bridge from North America. (One marsupial, the opossum, turned the tables and successfully migrated north.)

Before man, the only land eutherians in Australia were rodents and bats, and even they are comparatively recent arrivals; the marsupials were therefore free to develop into a richly diverse fauna.

## Impact statements

And so the Australian people are guardians of a large proportion, and an especially wide variety, of the world's remaining marsupials. How well equipped are we

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*It would be a mistake to label the pouched mammals primitive.*

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to conserve those that survived Aboriginal hunting and burning, and then the highly unsettling arrival of European man? The answer is, not at all well, but matters are slowly improving.

To conserve we must study, and that

takes time. Dr Hugh Tyndale-Biscoe and Dr John Calaby, of the CSIRO Division of Wildlife Research, point out that recent field investigations of individual species, sufficiently thorough to yield the information needed for effective conservation management, have taken from 4 to 7 years. This is far longer than the 6 months or a year within which biologists are often expected to prepare reports for environmental impact statements. As the researchers remark, 'reliable and worth-while information cannot be collected in a short time'.

In ecology a little knowledge can be a dangerous thing. If you know no more about the greater glider than that it lives among trees, you may suppose you can save it in commercial forests by simply collecting animals in the zone to be felled and releasing them elsewhere.

Dr Tyndale-Biscoe and Dr Roger Smith of the Australian National University put this notion to the test. In a 6-year study of the glider they found that individuals remain in their home range even after trees have been felled. Rather than attempt to wring an existence from nearby unfelled forest, the gliders stay at home and starve. Most die within a week.

Even when the researchers removed

A fat-tailed dunnart, *Sminthopsis crassicaudata*.







The greater glider: if the trees in its home range are felled, most individuals die within a week.

some gliders from a neighbouring area of intact forest to make ecological room for refugees from a felled zone, the victims of felling declined the invitation and stuck to their old haunts. The researchers comment that this study 'emphasizes the futility of attempting to transplant animals from a doomed habitat to another area which, if suitable for the species, is already occupied by a resident population'.

In an effort to soften the collision between mining and wildlife, the CSIRO Division of Wildlife Research has surveyed the ecology of several areas in the Northern Territory. Each investigation lasted years, not months, and it is easy to see why. Scientists need a whole year to follow an animal's breeding cycle, and they need at least 2 years to see the effect of variations in the weather.

These surveys involve all vertebrates except fish, but small mammals present some of the greatest difficulties. Most species disappear by day and emerge only after dark, especially in hot climates. Even when active, many remain secretive, and a survey entails much laborious live trapping and searching by spotlight.

### Miraculous generation

Every form of life possesses individual qualities that merit conservation, but the marsupials are more unusual than most. To François Pelsaert the 'generation' of wallabies was 'Very Miraculous', and to

modern zoologists reproduction is still the most distinctive feature of marsupial biology.

Pelsaert, however, failed to uncover the whole story. His journal generated a myth that endured for several centuries: '... under the belly the females have a pouch into which one can put a hand, and in that she has her nipples, where we have discovered that in there their Young Grow with the nipple in mouth, and we have found lying in it some Which were only as large as a bean, but found the limbs of the small beast to be entirely in proportion, so that it is certain that they grow there out of the nipple of the mamma and draw the food out of it until they are big and can run'.

To casual observers the sight of young at the teat implied budding, and that belief persevered until somebody finally witnessed a marsupial birth.

Although slightly less miraculous than Pelsaert imagined, the pouched mammals do order their reproductive affairs quite differently from the eutherians. Instead of investing large amounts of resources, in the form of energy and biological materials, in the development of an advanced foetus, the marsupials bear relatively rudimentary young that complete their development in the pouch.

Marsupial pregnancy can be remarkably short. Dr Gordon Lyne of the Division of Wildlife Research has recorded the briefest gestation known for any mammal: between 12 days 8 hours and 12 days 11 hours, in the bandicoot *Isodon macrourus*. Lactation, on the other hand, is more prolonged than in eutherians and,



On the Snowy Mountains in winter, small mammals live and feed under as much as a metre of snow. Ms Carron's traps are protected by bins.

all in all, marsupial reproduction is relatively slow.

New Zealand became the laboratory for an unintended large-scale demonstration of the contrasting rates of marsupial and eutherian reproduction when, in about 1850, rabbits and brush-tail possums, both plant-eaters, were introduced. The rabbit's rapid breeding raised it to pest status within 20 years, but the possum was not deemed a serious nuisance until 90 years after its release. In the long run the possum poses the greater threat, as it has taken to a wider variety of foods and habitats, and it is causing enormous damage to native forest plants (see the box on page 7).

### A bandicoot for all seasons

Small mammals show great variety in the timing and frequency of their breeding, a variety that is at least partly explained by the diversity of habitats to which different animals are adapted. A species can breed only when the environment supplies enough food to support not only busy parents but also a developing litter of young.

Some habitats meet this need all year round, and many marsupials take the opportunity to breed in all seasons. For example, Dr Lyne has shown this to be true of a bandicoot, *Perameles nasuta*,

The bandicoot *Isodon macrourus* has the shortest gestation known for a mammal.





which lives in eastern Australia and eats a variety of foods, chiefly insects.

The honey possum, too, breeds throughout the year. This Western Australian species has a quite different diet of nectar and pollen, which are always available in its habitat, the heathlands of the south-western corner of the State. Three Murdoch University researchers, Dr Marilyn Renfree, Dr Eleanor Russell, and Dr Ron Wooller, have found young honey possums in every month of the year, but the proportion of mothers with pouch young reaches three peaks — in autumn, winter, and spring. At these times, particularly large numbers of banksias and other heath plants blossom, and so the peaks of supply and demand coincide.

If the food supply regularly falls to a low level, an animal may be expected to have a well-defined breeding season. For instance, a marsupial mouse, *Antechinus stuartii*, which lives in forests and eats insects, so times the birth of its young that they are weaned in spring when food is plentiful. Handicapped by the long marsupial lactation, *A. stuartii* could not wean a second litter before autumn, when the populations of its prey species decline.

As if in deference to this ecological reasoning, several *Antechinus* species, including *stuartii*, close their reproductive options in an extraordinary way. By the

*Antechinus swainsonii*: all the males die soon after mating.

time the young are born, the adult males have all died. The females are scarcely more persistent; most disappear once their offspring have achieved independence, and fewer than one in five survive to breed again the following year.

*By the time the young are born, the adult males have all died.*

This phenomenon, in which males breed only once in their lifetime, is very rare among higher vertebrates, and among mammals it is known only in some species of *Antechinus*. (A close relative, *Phascogale*, possibly behaves similarly.) The *Antechinus* males die within a short time of each other, apparently genetically doomed to suffer both the breakdown of their immune system and severe stress induced by their aggressiveness during the mating season.

Some other small marsupials can fit more than one breeding cycle into the year. *Sminthopsis crassicaudata* provides an interesting example. This marsupial mouse, sometimes called the fat-tailed dunnart, is closely related to *Antechinus* within the family of dasyurids.

*Antechinus stuartii*, which changes its habits and time of breeding if *A. swainsonii* is present.



The mountain pigmy possum was for 70 years known only from fossil remains, until in 1966 one was found at Mt Hotham, Victoria. In 1970 a fauna survey of Kosciusko National Park by the CSIRO Division of Wildlife Research and the New South Wales National Parks and Wildlife Service discovered three more.

Although confined to more or less open country in southern Australia, its range encompasses a wide variety of climates, from regular coastal rains to the harsh extremes of the arid inland. Dr Stephen Morton of Melbourne University found that the females first come into heat with increasing daylight in spring, and the young are therefore born and weaned when their insect food is likely to be most abundant.

Even in an arid habitat Dr Morton found no evidence that the dunnarts wait for rain before breeding, as many birds do. Although this remains a possibility at the most arid extreme of the animal's range, where the dunnart has not yet been studied, no desert dasyurids have yet been shown to be 'opportunistic'; they live by the calendar, weaning their young in spring or summer.

The dunnart therefore resembles *Antechinus* in being a seasonal breeder, but differs in raising at least two litters in succession. Perhaps the later broods protect the species against a delay in the flush of insects. Dr Morton suggests that variability in the food supply (when will it come? how much will there be?) presents an even bigger problem than aridity for nocturnal insect-eaters in open habitats.

Breeding in winter would be impossible. The dunnart barely finds enough food to survive, and takes special measures to conserve its precious energy — sharing a communal nest, and even slipping at times into torpor. The fat stored in the tail probably helps, but not much; Dr Morton found that its energy would only keep the animal going for about half a day.

#### Evasive action

The environment consists of more than food and weather. Subtle interactions occur between some marsupial species,



Fern understorey in the Brindabella Ranges: the habitat of *Antechinus swainsonii*. If this species is removed, *A. stuartii* will invade the area.



The limit of the ferns and start of the drier slopes to which *Antechinus stuartii* is restricted in the presence of *A. swainsonii*.





A directory of Australia's marsupials			
family		total no. of species	endangered species
Dasyuridae	marsupial mice	33	4
	native cats, Tasmanian devil	5	
Myrmecobiidae	numbat	1	
Thylacinidae	thylacine	1	1
Notoryctidae	marsupial mole	1	
Peramelidae	bandicoots	11	5
Burramyidae	pigmy possums, feathertail glider	6	
Petauridae	ringtail possums, greater, sugar, and other gliders, Leadbeater's possum, striped possum	11	1
Phalangeridae	brush-tail possums, scaly-tailed possum, cuscuses	6	2
Phascolarctidae	koala	1	
Tarsipedidae	honey possum	1	
Vombatidae	wombats	3	1
Macropodidae	rat kangaroos	10	6
	wallabies and kangaroos	37	9
		total 127	29
The species listed as endangered include some that have not been seen for a long time and are possibly extinct.			
A summary of the other mammals			
Monotremes (lay eggs: 2 families)		total 2	
Eutherians	rodents	51	
	bats (6 families)	56	
	dingo	1	
	sea lion, fur seals	3	
	elephant seal	1	
		total 112	

Marsupials make up just over half of Australia's native mammal species. The list excludes animals introduced by European man.

which zoologists do not yet fully understand. For instance, where the ranges of two species of *Antechinus* overlap, their breeding seasons shift apart. Thus *A. stuartii* on its own may breed at about the same time as *A. swainsonii*, but where they coincide *stuartii* delays its breeding by about a month, by which time the *swainsonii* males have died.

In the Brindabella Ranges near Canberra *stuartii* overlaps *swainsonii*, and Mr Chris Dickman of the Australian National University thought it would be interesting to see what happened if he removed one species.

Taking out *stuartii* had little effect on *swainsonii* but, in the converse experiment, when *swainsonii* were evacuated *stuartii* reacted dramatically, spending more time on the ground, where *swainsonii* normally feeds, and less in trees. The proportion of young *stuartii* surviving for 3 months after weaning rose from half to about three-quarters.

These responses are perhaps partly to do with diet, but almost certainly involve a direct interaction between the two species. Although *swainsonii* does not appear to act aggressively, *stuartii* takes evasive action.

Put them together in a cage and, while *swainsonii* strolls unconcernedly about, *stuartii* tries to escape, finally hanging upside down from the roof of the cage. This avoidance seems instinctive: even *stuartii* reared in the laboratory show the same reaction.

While studying rodents in the Snowy Mountains, Ms Pippa Carron, also of the Australian National University, had the opportunity to investigate *A. swainsonii*. At about 1600 m, these are the first high-altitude *Antechinus* to be investigated. Although they spend the winter under about 1 m of snow, they achieve a higher population density than in the Brindabellas. However, they wait for warmer weather before breeding, and their young are born

about 2–3 months later than at low altitudes.

Reproductively the marsupials may be bizarre besides eutherians, but in the rest of their physiology and behaviour they are apparently orthodox. To take just one example, the rabbit-eared bandicoot *Macrootis lagotis* meets the challenges of arid inland existence with adaptive devices familiar to students of desert eutherians, such as low water turnover thanks to concentrated urine and relatively dry faeces, and the habit of sheltering by day in a cool, humid burrow.

It would be a mistake, therefore, to label the pouched mammals primitive. Marsupials are constructed to a biological plan so flexible that different species occupy almost all the major ecological niches: in forests some eat foliage, some nectar, and yet others insects or larger animal prey; open places support further insectivores and species that eat grass.

Zoologists call such an evolutionary divergence into different ways of life an adaptive radiation, and the radiation of marsupials displays remarkable parallels with that of eutherians. Of the parts to be played on land, only true flight and seed-eating are absent from the marsupial repertoire, and South America boasts several species that are at home in water, including one, *Chironectes minimus*, with webbed hind feet.

### Measuring appetites

These, then, are the marsupials: biologically distinctive yet diverse. How can we minimize the risk of losing the species that remain? The answer is by learning all we can of their needs, especially their food and their habitats.

Diets can be difficult to study, especially when you want to know not only what an animal eats but also how much it requires to survive. Dr Brian Green of the Division of Wildlife Research has been tackling this problem, and has developed a technique that promises to help solve it for carnivores. The technique is a variation on a widely used method of measuring an animal's water turnover. That method involves injecting into the blood a known quantity of 'labelled' water containing tritium, a radioactive isotope of hydrogen, retrapping the animal a few days later, and measuring the dilution of the injected sample. The more the 'labelled' water has been diluted, the more water the animal must have taken in since it was first caught.

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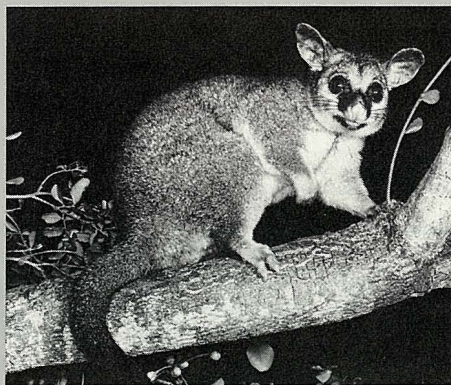
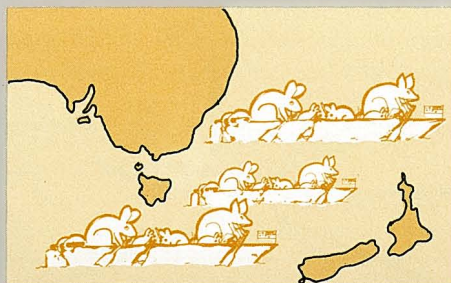


## Possum problems in New Zealand

In the 19th Century, New Zealanders looked enviously at Australia's brush-tail possum, and its valuable fur, and thought what a useful addition to the local fauna it would make. Now they are not so sure.

The trouble is that in New Zealand the possum has no serious competition for its leafy diet, and its numbers have gradually built up to pest proportions. The fossil record suggests that when New Zealand split from Australia and Antarctica about 80 million years ago land mammals were absent, and none of the other species subsequently introduced by man climbs trees. The leaf-eating insects called phasmids come nearest to being ecological rivals to the possum.

The first brush-tail possums were imported in the middle of last century, and large numbers arrived from Tasmania, Victoria, and New South Wales from 1890 onwards. Although the species was slow to increase, it has become the best-established and most widespread mammal in New Zealand. Rabbits, first intro-



New Zealand's most widespread mammal is an Australian export: the brush-tail possum.

### *In New Zealand, the possum has no serious competition.*

duced at about the same time as the earliest possums, do not stray far from agricultural land, but possums are found not only on farms and in suburbs but also throughout both native forests and plantations of exotic pines.

A study in 1919 judged possum damage insignificant and outweighed by the value of the skin trade. By the 1940s things had changed. The possum had become sufficiently abundant to attract a bounty in 1951, and for 8 years an average of one million possums a year were killed under the scheme. The campaign made no detectable dent in their population and the bounty was withdrawn.

Careful ecological research by CSIRO's New Zealand counterpart, the Department of Scientific and Industrial Research, has revealed both how drastically the possums are affecting native forests and why they are difficult to control.

A study by Miss Ruth Mason of DSIR's Botany Division in the Orongorongo valley in 1946–47 showed that the animals enjoyed a relatively uniform diet, with a

marked preference for four plant species: *Fuchsia excorticata*, *Metrosideros robusta*, *Alectryon excelsus*, and *Weinmannia racemosa*.

In a further study a quarter of a century later, Mrs Alice Fitzgerald of DSIR's Ecology Division confirmed that the possums fed mainly on a few favoured species, but *Fuchsia* and *Alectryon*, which are both woody shrubs, had disappeared from the menu and some new plants had joined it. Previously abundant, both *Fuchsia* and *Alectryon* had become scarce, and the few remaining specimens were heavily browsed. It seemed the possums had turned these two species into rarities and were transferring their attentions to alternatives.

The density of possums was much as it had been in the late 1940s, about six per hectare, or some five or six times the density in Australian forests. In other words, the possum population appeared stable but, under heavy browsing pressure, the native forest was changing.

To find out more about this pressure Mr Michael Meads, also of the Ecology Division, studied several specimens of *Metrosideros robusta*, the northern tree rata, for some years. What emerged is both interesting and disturbing: the possum's behaviour is gradually eliminating this tree, too, from the forest.

The possums converge on a few trees,

ignoring the others. Unlike phasmids, which nibble the leaf blade, possums tear away the entire leaf, stalk and all. The leaves of the rata normally persist for 3–4 years, but possums destroy them even before they are fully grown. Increasingly defoliated, the trees slowly starve to death.

Mr Meads protected the crowns of five browsed trees with anti-possum barriers and four fully recovered, but of 50 unprotected trees 10 had died within 5 years. Since the rata normally lives for more than 200 years, the possums are making a terrible impact.

Control of possums is hard because about one-third of them die each winter in any case. To reduce the population, man must augment this mortality. Moreover, scientists know that brush-tail possums can produce more young than they do in the dense, stable population at Orongorongo. A cull would be likely to put possum reproduction into higher gear, without reducing their numbers.

Where forest abuts upon cattle pasture the possums bring another threat. In 1970 brush-tail possums in New Zealand were found to be infected with bovine tuberculosis, and they may be reinfecting cattle. The New Zealand Forest Service has been studying the interactions of the two species. Possums and cattle come into contact when the possums invade up to several kilometres into farmland for food, especially clover, or when cattle take to the forest for shelter or to browse.

The problem is worst in the Buller district of South Island. Here cattle pastures extend over cleared river flats in valleys bounded by steep forest. The poison 1080 (sodium fluoroacetate) has been dropped on the forest from the air, but this measure has doubtful value.

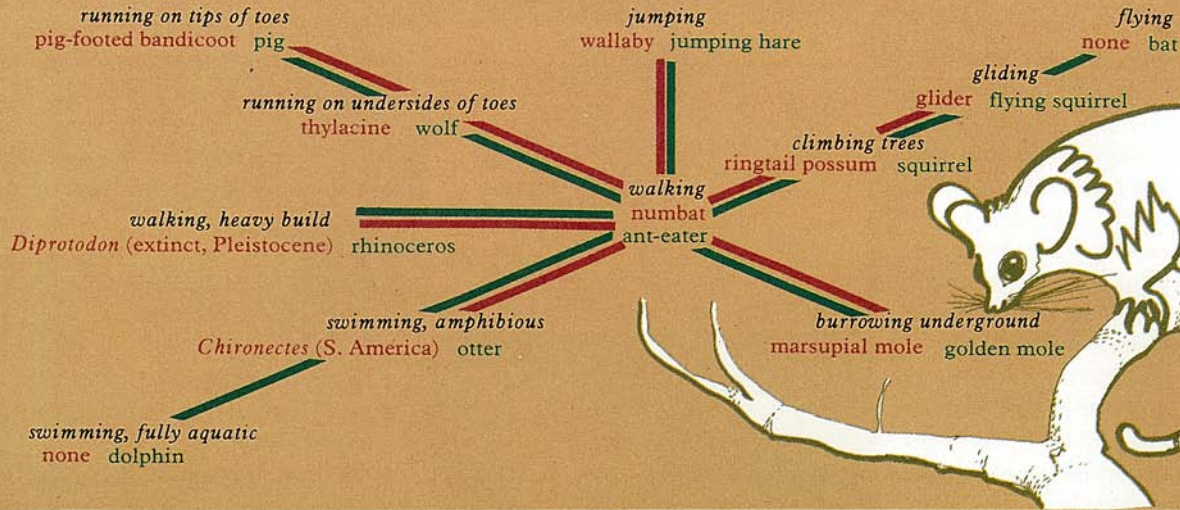
We know that possum populations have a great capacity for recovery, and that other species, especially native birds, could be killed by 1080. In any case aerial poisoning is expensive and the operation, at \$12–14 for each head of cattle to be protected, hardly pays.

One solution may lie in that fur. Exports of possum skins already earn New Zealand several million dollars a year. Besides, the rest of the possum is said to make good eating.

Ecology of small marsupials. C.H. Tyndale-Biscoe. In 'Ecology of Small Mammals', ed. D.M. Stoddart. (Chapman and Hall: London 1979.)



## Marsupial diversity



A honey possum on *Banksia coccinea*.



Different ways of getting about: the adaptive radiation of marsupial locomotion (red) parallels that of eutherians (green). Both these mammal groups also show radiation of other characters, for example teeth and diet.



A sugar glider in flight.

It occurred to Dr Green that something similar may be possible for estimating the intake of solid food. Knowing that all vertebrates have much the same concentration of sodium in their tissues, he argued that the uptake of sodium by an animal eating only vertebrate prey should provide a measure of the total quantity of food consumed. 'Labelled' sodium could be injected in the form of a salt solution containing the radioactive isotope sodium-22.

The technique was tried on captive dingoes and rabbits, and the dilutions correlated well with the amounts of food the animals ate. (Rabbits are not carnivorous, but the quantity and sodium content of their diet were known.)

It gave very good results too with caged Tasmanian devils and native cats (*Dasyurus viverrinus*). The next step will be to use it in the field.

A few months ago Dr Green returned from a visit to the United States, where he gained experience with another isotope, oxygen-18. He plans now to use more than

one 'labelled' element at a time, and so calculate an animal's energy consumption in the wild.

This kind of work could help answer a number of ecological questions, such as how much more energy animals need in winter or when lactating, how far predator numbers affect the size of prey populations, and what may be the carrying capacities of reserves managed for wildlife conservation.

### Rare possum

The necessity for suitable habitat is well illustrated by a small marsupial that hit the headlines in 1961, at which time it had not been seen for 52 years. Leadbeater's possum has been found at about 50 places, all within an area of only a few hundred square kilometres, and its prospects for survival were unknown when Mr Andrew Smith of Monash University began a recently completed ecological study of the animal.

One of Mr Smith's first tasks was to trap live specimens, something that had never

been done. Capturing agile possums that build their nests from 12 to 35 m above ground, emerge only at night, and then spend much of their time in the canopies of tall trees requires determination anywhere, and doubly so in the central highlands of Victoria, where snow is an additional handicap in winter. After 8 months his tally stood at two, both caught in butterfly nets.

He then hit on the idea of climbing trees and setting traps at nest entrances. Soon he was regularly catching the members of four possum colonies. He fitted each animal with a coloured reflective ear tag for identification by night.

Mr Smith found that a colony is a family group, consisting of one breeding female with one or more adult males and youngsters of both sexes. Each colony defends several nests against the members of other colonies.

The possums make their nests in large hollow mountain ash trees, *Eucalyptus regnans*. About half the nests so far found have been in living trees and half in dead





Leadbeater's possums eat tree crickets all the year round.

ones. The nests, which may be 30 cm in diameter, are constructed of shredded mountain ash bark.

Leadbeater's possums enjoy a catholic diet. Most of their carbohydrate comes from plants. They cut small holes in the bark of wattles and later return to lick the exuding sugary gum, as well as drinking sap escaping from plant wounds inflicted by insects. They also obtain plant sugars less directly in the form of honeydew, the waste product of some sap-sucking insects that consume more sugar than they need.

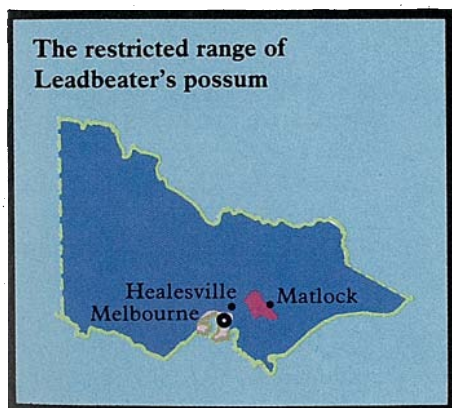
The possums turn to invertebrates for their protein, hunting on leaves and under bark for insects and spiders and reaping a harvest of tree crickets all the year round.

Mr Smith's study has identified a threat



Leadbeater's possum is threatened by an impending shortage of suitable habitat.

All the known colonies of Leadbeater's possum occur in mountain ash forest east of Melbourne.



looming on the possum's horizon. The huge bushfires of 1939 killed much of the forest. Those dead trees that house many of the possum nests cannot be expected to stand much longer, weakened as they were by the fire, and the regrowth forest, now just over 40 years old, will not develop suitable hollows for perhaps another 80 years.

Before long the possums could face several decades of severe housing shortage, especially if the forest is not managed with their particular habitat requirements in mind. The possums run and jump from tree to tree, and their speed and hunting efficiency increase with the density of undergrowth. In more open forest they travel less efficiently, and Mr Smith believes this could be a crucial consideration during winter when food can be hard to find.

### *Before long, Leadbeater's possums could face several decades of severe housing shortage.*

The part of the forest where Leadbeater's possum lives is scheduled to be clear-felled, one area after another in rotation. The challenge to conservationists is no longer to identify the animal's main needs, but to ensure that suitable areas of mature ash with thick understorey are always available.

### Road glider

Close study of a relative of Leadbeater's possum, the sugar glider *Petaurus breviceps*, has revealed that it too thrives in particular habitats, although this animal has benefited from some of man's practices. Mr Graeme Suckling, another Monash University zoologist, has found the glider especially numerous in Victorian roadside verges, sometimes only one tree wide.

The gliders feed on insects and plant products, with a special liking for acacia gum. They also bite into eucalypts to tap the flow of sugary sap from severed phloem ducts.

The roadside strips of vegetation attract sugar gliders because there the acacias, rarely grazed and regularly burnt, regenerate well. The strips therefore act as far more than bridges between remnant stands of forest on farmland. Acacias need fire to stimulate germination, but in the farm stands burns are rare and the few

seedlings have a strong chance of being grazed by stock.

Mr Suckling found that the sugar glider populations in roadside verges were thriving, unlike the one in a nearby 1.5-ha block of woodland, which apparently contained only one female. Because the gliders devour large numbers of insects, including some that are agricultural pests, it may well be to farmers' advantage to apply Mr Suckling's finding to the management of their remnants of woodland.

The conservation of Australia's marsupials depends on those scientists and others who find these creatures intriguing, challenging, 'Yea, worthy to note'.

John Seymour

### More about the topic

Gestation period and birth in the marsupial *Isoodon macrourus*. A.G. Lyne. *Australian Journal of Zoology*, 1974, 22, 303-9.

Eucalypt forests as refuge for wildlife.

C.H. Tyndale-Biscoe and J.H. Calaby.

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An ecological study of *Sminthopsis crassicaudata* (Marsupialia: Dasyuridae). III. Reproduction and life history. S.R. Morton. *Australian Wildlife Research*, 1978, 5, 183-211.

Water metabolism in perameloid marsupials from different environments. A.J. Hulbert and T.J. Dawson. *Comparative Biochemistry and Physiology*, 1974, 47, 617-33.

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Energy requirements and sodium and water turnovers in two captive marsupial carnivores: the Tasmanian devil, *Sarcophilus harristii*, and the native cat, *Dasyurus viverrinus*. B. Green and I. Eberhard. *Australian Journal of Zoology*, 1979, 27, 1-8.