Forests and flying foxes: *partners in survival*

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Top: The Large-eared flying fox, *Pteropus macrotis epularis*, a New Guinea species recently discovered to inhabit the Torres Strait region.

Above: Recorded distribution of megachiropteran bats in Australia.

Right: An as yet undescribed species of flying fox known only from a population of about 2000, found just a few years ago on an island in Torres Strait.

Opposite page: A flying fox in flight, showing the arrangement of the 'hand wing' that distinguishes bats from all other mammals.

Flying foxes assist regeneration in many Australian forests, but their numbers appear to be declining. Research at the Division of Wildlife and Ecology offers hope that with appropriate conservation reserves, these fascinating creatures can be protected.

For thousands of years, flying foxes have followed the regional flowering and fruiting patterns of Australia's native forests on their seasonal migrations. In return for their feasting, they play a vital role in forest regeneration, pollinating and scattering the seeds of many eucalypts and rainforest species.

But declining forests habitats have lowered natural food supplies, sometimes forcing the flying foxes to 'raid' commercial orchards. Many are killed each year by orchardists who, understandably, regard them as pests. Today, five flying fox species are rare, two are vulnerable, and one is extinct.

Beyond the immediate issue of bat conservation lies a broader problem: the effects of their decline and altered migration patterns on forest ecology. Flying foxes are vital in sustaining forests as working ecosystems. Without them, forests will degrade, losing many species, perhaps within just a few tree-generations.

Despite the gloomy outlook, CSIRO's Greg Richards believes that with a network of reserves in 15 'critical conservation areas', all species of Australian bats can be preserved. And if orchardists can be helped to predict the migrations of flying foxes, nets or other deterrents can be used to make sure that their fruit remains on the trees.

Richards regards flying foxes as among Australia's most diverse and fascinating animals. His association with bats began in 1968 when he joined his colleague Les Hall on a bat-studying field trip. Richards was 'hooked' immediately, and has since pursued the passion, often during his leisure.

Richards studies the biogeography, taxonomy, and ecology of bats at the Australian National Wildlife Collection, part of the Division of Wildlife and Ecology at Canberra.

Richards and Hall (now at the University of Queensland) prepared a bat conservation action plan at the request of the Endangered Species Unit of the Australian Nature Conservation Agency (ANCA), formerly Australian National Parks and Wildlife Service.

Apart from this work, Australian bats are a poorly studied group. Only 3% of Australia has been adequately surveyed for conservation assessment. Some 90 species have been identified in Australia, (12 flying foxes) and more are expected to be added as research continues.

Flying high

Dr Jack Pettigrew, a University of Queensland neurophysiologist, stunned the world in the 1980s with the controversial hypothesis that flying foxes share a common ancestry with primates. His theory was based on the similarity of many characteristics of the brain, including the pattern of the optic-nerve pathway. Insect bats are different, and have brains similar to most other mammals.

Subsequent genetic evidence has revealed that insect bats and fruit bats probably arose from different evolutionary groups: insect bats from from a shrew-like ancestor, and flying foxes from near the lemur branch of the primate tree. The two bat groups differ in both their appearance and habits.

A flying fox hangs, toes to the sky, facing forward, holding its head at a right angle to the chest, or with its chin tucked down onto it. Insect bats hang with their throats stretched and exposed, facing as if to watch for what may approach from behind. Also different are their wing and skull anatomies and sensory systems. Insect bats specialise in analysing sound. Flying foxes locate food by sight and smell.

Richards says flying foxes are loaded with personality and are far more intelligent than the insect-eaters. They also have a richer social life and a more interesting ecology.

Flying foxes occur naturally in Australia, Africa, Asia, and Melanesia. Australia's flying fox species apparently migrated south through South-East Asia and New Guinea about 2.6 million years ago. They now favour the warm eucalypt and rain forests of Australia's northern and eastern coasts.

Each species belongs to one of five ecological groups: large (greater than 300 grams) and small (less than 60 g) specialist fruit-eaters; large and small nectar-specialists; and large generalists. Each group contains at least one common species and one or more rare species.

Flying foxes require huge quantities of food to fly and stay warm. To minimise the weight carried around in flight, they can digest food in 12 minutes. They also have developed special feeding habits which contribute to their useful role in the forest.

Only one choice of food type exists on the flying fox menu: fruit or nectar. These delicacies are presented in visible clumps at the ends of tree branches. Leaves are occasionally eaten too, perhaps as dessert!

Fruit smoothies

Fruit bats maximise the return from a quick meal by masticating fruit with strong jaws and molars. With raspy tongues, they then pulp it against their ridged palates, swallow the juice, and spit out the pulp. Small seeds are also swallowed. In greenhouse experiments with Spectacled flying-foxes, (*P. conspicillatus*) Richards has observed the seeds to pass through unharmed.

Like many social mammals, fruit bats are highly territorial and they defend an area of tree space about three metres in radius. Territory-holders push invading animals (raiders) from one territory to another, and finally out of the tree. This social behaviour helps to disperse seed.

Richards has observed that on most occasions the raiders depart with a fruit in their mouth: a small reward for so many arguments! By taking the fruit some distance away to eat it, the seeds are dropped and dispersed. Other studies have shown that seedlings growing away from the parent tree have a better chance of success, thus

Hurricane reveals seed-dispersal role

After a five-hour battering from Hurricane Hugo in 1989, Puerto Rico's Luquillo rainforest was devastated. According to an article in *New Scientist*, however, ('Bats sow seeds of rainforest recovery,' June 18, 1994) the hurricane was fortuituous because it gave biologists a unique opportunity to assess the effects on bat populations of a major forest upset.

Biologists from Pennsylvania State University and Texas Tech University had begun studying the bats of Luquillo two years before the hurricane hit. They reported that two bat species – the Jamaican fruit bat (*Artibeus jamaicensis*) and the greater Antillean long-tongued bat (*Monophyllus redmanii*) – managed to escape. But the red fig-eating bats (*Stenoderma rufum*) are weaker fliers. When the other species left the wrecked forest, they clung to their roost sites in the barren canopy, exposed to wind, heat and rain.

Two years later, the Jamaican fruit bats had returned in full force, and Antillean long-tongued bats were more numerous, probably nourished by lush new growth on the sunnier forest floor. During the same period, however, red fig-eating bat populations fell steadily and biologists felt that the species might not recover. The red fig eating bat is so rare that until the late 1950s it was known only from fossils and was thought to be extinct. Puerto Rico may be its only remaining habitat.

By attaching radio transmitters to the backs of bats, biologists found that the fig-eaters had to forage over a much wider territory to find food. Young bats simply disappeared, apparently unable to cope with the harsh conditions. And the number of pregnant and lactating bats fell dramatically, perhaps because the females were investing all their energy in survival, or because the remaining bats were so widely scattered that males and females rarely met.

But scientists are now cautiously optimistic about the future of this bat, after netting and releasing a few juveniles and pregnant females last year.

Ironically, because the red fig-eating bats remained in the forest, they have played the largest role in helping it to recover from the hurricane. This bat is thought to be the only agent for dispersing the seeds of at least one of the dominant species of tree in the forest, *Manilkara bidentata*. If the seed dispersers from those trees are not present, the forest is not going to return to its previous state. The biologists found that the removal of one species can potentially change the entire structure of the forest.

maximising the reproductive success of that species.

Research overseas shows that many rainforest tree species, including several keystone species (those shaping the whole community), depend on fruit bats for seed dispersal (see box story).

Nectar lovers

Nectar feeders, the other group of flying foxes, pollinate many of the eucalypt-forest species, including shrubs such as banksia. This group includes the Macroglossinae: weak chewers with long, tapered muzzles and specialised tongues for deep flower penetration.

Flying foxes land on flowers to drink from nectaries, transporting pollen. Arriving with a thump, blossom bats liberate a cloud of sticky pollen, much of which clings to their fur and remains viable at the next plants. Many flowers may have co-evolved with bats to benefit most from the rough treatment

While other animal groups (insects and birds) also pollinate eucalypt-forest flowers, none cover adequate distances to achieve consistent out-crossed pollination. Eucalypts of the same species may stand 50 m apart, the distance potential pollinators must travel to achieve fertilisation. Birds and insects rarely move this far, but flying foxes do so with ease.

Peggy Eby from the National Parks and Wildlife Service of NSW has radio-tracked Grey-headed flying-foxes (*P. poliocephalus*). She says they visit several trees a night from each of a few different stands, often kilometres apart.

Previous studies measured how efficiently eastern blossom bats (*Syconycteris australis*) pollinated flowers. The bats were found to spend less time at each rainforest tree than other pollinating species, but transported more pollen over wider distances than did any other pollinator (birds, moths). This cross-pollination avoids inbreeding among nearby trees, thus maintaining genetic diversity.

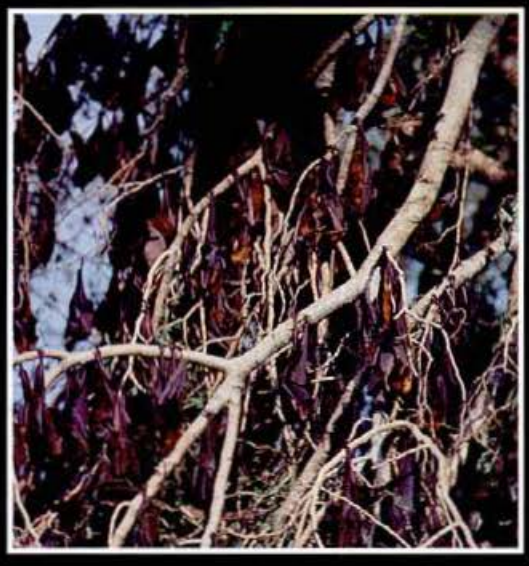
The apparent co-dependency of flying foxes and so many tree species has an important consequence. Many trees cannot reproduce without this seed dispersal or pollination, yet flying fox migrations depend on flowerings of varying predictability.

The search for food

In the 1920s, Francis Ratcliffe, the inaugural leader of CSIRO's Wildlife Survey Section, studied flying fox camps that covered many hectares and often numbered half a million individuals. Camps of this size have not been seen for several decades, an indicator that some populations are decreasing.

Doug Wahl, a masters student of Canberra University, found that in the north-coast region of New South Wales alone, orchardists culled 240 000 flying foxes from 1986-92. It would seem impossible for flying foxes to sustain this mortality for long.

Most flying foxes migrate in their



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Top: Part of a colony of Little Red flying foxes, *Pteropus scapulatus*. They have a distinctive manner of roosting close together, as opposed to being spaced apart, as with other flying foxes. These animals, weighing an average of 350 grams, can break major branches of eucalypt trees just by their sheer total mass.

Middle: One of the many hazards from humans that kill flying foxes is the common barbed wire fence. This is a young Black flying fox at Chillagoe, north Queensland.

Above: Always keen to spread the good word. Greg Richards shows school children on Moa Island (Torres Strait) the wonders of bats, animals that they rarely see in their local environment. He is holding a Queensland Tube-nosed bat, a sub-canopy seed disperser of our tropical rainforests.

Opposite page: A cauliflorous (trunk-fruiting) rainforest tree on the Atherton Tableland, north Queensland. Although this tree has a suite of pollinating animals, small (15 gram) blossom bats are not only the most successful at pollinating flowers, but appear to be the only agent there that moves pollen between rainforest patches.

search for food and warmth. Richards says that if timing and direction these migrations can be predicted, orchardists can be warned in time to erect protective nets around their fruit. Given this kind of notice, some orchardists could even leave a few trees unprotected to help quench a few hearty appetites.

In the wild, abundant and continuous supplies of flowers or fruit are rarely available. Some species, such as the Grey-headed flying fox, (*P. poliocephalus*), migrate thousands of kilometres each year, such as from Lismore to Nowra, a distance of more than 700 km.

Predicting the migrations involves understanding the flowering patterns of the bats' main food sources. Blossom-feeders predominantly utilise eucalypts, which flower according to a loose seasonal and sequential pattern, often blooming along altitudinal and/or latitudinal gradients. These highly unreliable food sources flower in patches, not always annually, depending mainly on rainfall.

Blossom-feeding flying foxes travel extensive spans in search of the high quality (rich in nectar and protein) flowers that are only produced following abundant rainfall (such as in the Gulf of Carpentaria). As a result, their travels can be predicted easily by monitoring rainfall patterns and timing.

In contrast, most rainforest species flower at specific times each year, or every second year. Regional flowering and fruit-ripening sequences follow set patterns (coastal, then highland areas) after a known interval. Fruit bat migrations in north Queensland reflect this regular food supply.

In some areas, however, habitat fragmentation appears to have altered the flying foxes' natural migration patterns. They must now move further between diminishing forest remnants, running the gauntlet of varying levels of legal protection in different states.

It is partly because of habitat fragmentation that flying foxes have become 'pests' in some areas. They only appear to raid orchards as a desperate measure when starving. Flying foxes would apparently leave orchards alone if their habitat could support them.

An inventory of Australia's bat populations formed part of the bat conservation plan prepared by Richards and Hall. The inventory revealed that 14 mostly-tropical regions support 20 or more bat species (including insect-bats) each, a total area of only 58 000 km^2, or 0.1% of Australia. The plan outlines which regions are adequate for preserving Australia's species.

The good news is that preserving all endemic (unique to Australia) and other species requires only 15 critical conservation areas. These would represent more than 50 species at least twice. Seven areas already contain reserves and forming new reserves to complete the network (one in NSW, two in Western Australia and five in Queensland) requires the assistance of only three state governments.

Developing the conservation network may take tremendous time and effort, but at least the importance of the flying fox within it is now recognised. Our future may well depend upon the survival of these fascinating creatures.

More about bats

Richards GC (1994) A review of ecological interactions of fruit bats within Australian ecosystems. *Symposia of the Zoological Society of London, Vol. 68* (in press).

Richards GC (1993) A review of the Australian action plan for bat conservation. *Australian Bat Society Newsletter*, No. 2, July 1993, 9-12.

Morecroft R (1991) *Raising Archie: the story of Richard Morecroft and his flying fox*. Simon & Schuster, East Roseville NSW.

Deeker W (1993) Fragmented Landscapes: Is our wildlife in danger? *Ecos*, 77:30-34.