An Armoury of Adaptations: Desert Fauna

> *… from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved*.
>
> Charles Darwin[1]

> Any glimpse into the life of an animal quickens our own and makes it so much the larger and better in every way.
>
> *John Muir*[2]

Ancient Fauna: Casualties of Climate Change

Surviving the cataclysmic geological history and turbulent climatic changes of the Australian continent depends on adapting to change, and that, in turn, requires a gene pool sufficiently large to produce genetic variations. Successes are rare, especially when changes occur rapidly. On the geological time scale, there have been mass species extinctions resulting from climate changes when the inland seas evaporated and waterholes dried up suddenly and irrevocably.

In Canowindra, in Western NSW an amazing haul of over a hundred fossils of fresh-water Devonian fishes was discovered by accident, closely packed in a slab of rock. This mass mortality of now-extinct species occurred some 360 million years ago (may), when the fishes were trapped in a dwindling water hole as the river that fed it dried up.

Slab of rock with fossilised fish at the Age of Fishes Museum, Canowindra, NSW.

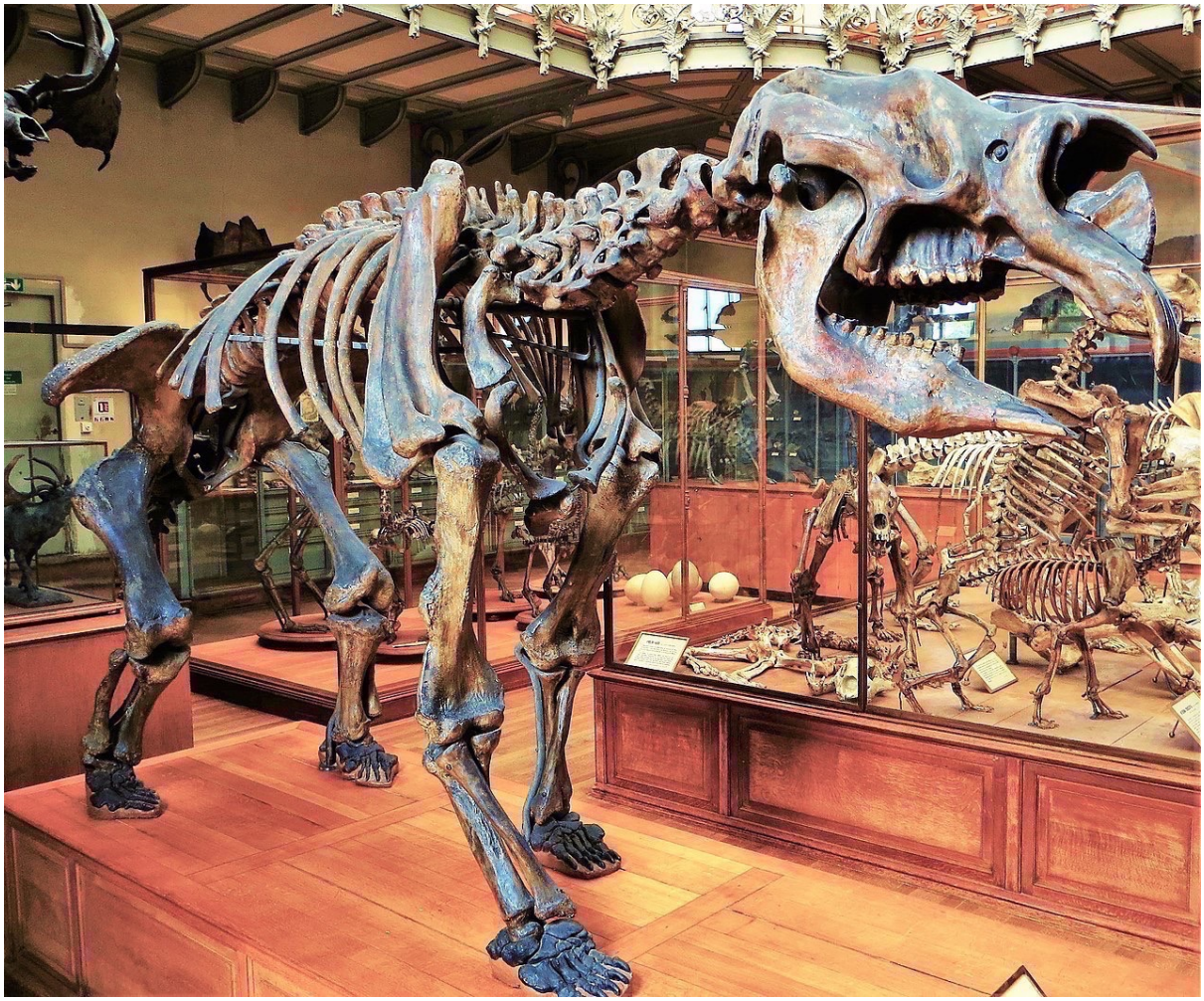
Where changes occurred more slowly, some of these early fishes were able to evolve to take advantage of different environments. During the late-Devonian period, for example, Sarcopterygian (lobe-finned) fishes developed lungs as well as gills and bony supports inside their fins, enabling them to crawl onto land and breathe air, thereby surviving the drying up of water sources.

Similar casualties befell the dinosaurs and marine reptiles that inhabited much of Central Australia during the Cretaceous period around 100 mya. Opalised fossils of extinct icthyosaurs, plesiosaurs, and the giant pliosaurs that swam in the shallow Eromanga Sea covering Central Australia, have been found. On land, giant sauropods, such as the eight-metre long *Muttaburrasaurus* and *Minmi,* as well as smaller plant-eating dinosaurs once flourished.

Reconstruction and skeleton of *Muttaburrasaurus langdoni*.

But they, too, failed to adapt when a massive asteroid about eleven kilometres wide slammed into what is now the Gulf of Mexico around 66 mya, sending a plume of vaporised rock into the air, This created an extended 'impact winter', blocking sunlight from the Earth for months and causing the extinction of 90 per cent of the plants on which their food-chain depended (Chiarenza, Farnsworth, Mannin et al., 2020). depended.[3]

The demise of the dinosaurs freed up a survival niche for small, unspecialised mammals to evolve into a diverse array of terrestrial, aquatic and flying forms. These mammals were either monotremes or marsupials; placental mammals, even if they reached Australia, seem not to have survived and when the continent finally severed from Antarctica 45 mya, and moved north, it carried an ark of unique mammals which developed into megafauna, including *Diprotodon australis*, a relative of wombats and koalas but, at 3 metres long and 2 metres high, the largest marsupial that has ever existed, *Procoptodon goliah*, the giant short-faced kangaroo, and *Zaglossus hacketti*, a giant echidna.[4]



Cast of *Diprotodon australis* skeleton, French National Museum of Natural History, Jardin des Plantes, Paris.

These megafauna probably came to prominence during the glacial conditions of the last ice age, but became extinct for reasons that certainly included, but were not wholly explained by, climate change. With the end of the long glacial or Pleistocene epoch, the sea level rose, causing inundation of former grazing areas. Simultaneously, as Australia's climate changed from cold-dry to warm-dry, most inland lakes dried up, removing their grazing habitat from the centre of the continent and driving the remaining mammals into a narrow strip of Eastern Australia. Here they survived until about 7,000 years ago, and thus co-existed with Indigenous peoples for at least 30,000 years, indicating that they were not, as has been variously proposed, either hunted to extinction by the Aborigines, or victims of habitat loss through uncontrolled burning. It seems more likely that they were rendered extinct through climate changes associated with the last ice age (Bowman2013). age[5]. Whatever the reasons for their demise, these casualties of evolution are stark examples of an inability to adapt to changing environment and habitat.

Desert fauna that have survived to the present have adapted to an extraordinarily hostile environment. Searing daytime heat, cold nights and oscillating periods of drought and floods are the main challenges facing desert animals. In order to endure such adverse conditions, they, like the desert plants, considered in the previous

chapter, have evolved an impressive array of adaptive mechanisms, many hidden from the casual observer. Some do not drink but derive sufficient water from ingested food; some conserve water by excreting highly concentrated urine; others store quantities of food as fat in times of plenty. Many avoid water loss through evaporation by remaining underground during the heat of the day, emerging at dusk to hunt or scavenge; some defer reproduction until conditions are favourable. Some, like birds, migrate to more favourable areas.

Birds

Many desert bird species are strictly nomadic, constantly wandering across vast areas, seeking locations where rain or flooding has generated a burst of plant growth or insect activity. Budgerigars live in continuously wandering flocks, following the flushes of food when native grasses, stimulated by episodic rainfall, produce seed heads. Like the ephemeral plants, these nomadic species are opportunistic breeders, taking advantage of good conditions to mate and raise young without regard to any specific season.

Seasonal wetlands are important habitats for birds, especially as a breeding ground for waterbirds, while rivers nurture birds, bats and frogs. The Lake Eyre ecoregion, which includes the Coongie Lakes and the swamps that result from the flooding of Cooper Creek, Strzelecki Creek and the Diamantina River, attracts multitudes of birds, including ducks, gulls and ibis. In flood time, the trees lining Cooper Creek are white with shrieking corellas, and pelicans sail majestically on its waters.

Australian pelicans (*Pelecanus conspicillatus*) at Coongie Lakes

Equally important for survival are the artificial wetlands created by Purnie Bore and other mound springs arising from the Great Artesian Basin, where white cockatoos and galahs shriek joyfully and the ubiquitous crested spinifex pigeons (*Geophaps plumifera*) are thick on the ground.

Spinifex pigeon (*Geophaps plumifera*)

For less mobile species, endurance through unpredictable droughts or floods demands frugality in energy use, usually through changes in levels of activity or management of temperatures.

Insects

One of the most sophisticated and conspicuous adaptations by insects is that of termites (*Isoptera sp.*), often wrongly called 'white ants' (they are more closely related to cockroaches than to ants). Termite eggs require strict temperature control to within one degree of optimum (Australian Museum 2019). optimum[6]. To achieve this in the intense heat of the inland and especially the Northern Territory, termites erect extraordinarily efficient air-conditioned edifices to regulate the temperature inside their mounds and their associated networks of tunnels, arches and nursery chambers. These constructions are of two kinds: giant 'cathedral' mounds that tower up to four metres above the ground and the thin, 'magnetic' mounds, three to four metres high. The latter,

produced by the compass termite (*Amitermes meridionalis*), are thicker across the east-west axis than across the north-south axis. This alignment exposes the smallest possible surface to the mid-day sun, while allowing the eastern face to be warmed in the morning, followed by a plateau in temperature until sunset. The column of warm air rising out of the nest produces circulation currents throughout the network. During the winter season large numbers of termites, including workers, larvae and reproductive nymphs, move in the morning to the eastern face, which warms first, and remain there during the day (Jones and Oldroyd 2006). day.[7]

Magnetic termite mounds in the Litchfield National Park, Northern Territory.

Termite 'cathedral' mound, Northern Territory.

For Australian mulga ants (*Polyrachis macropa*), the greatest danger is not soaring temperatures but flooding. To avoid inundation, they surround the entrance to their underground nest with a cylindrical wall of soil and a palisade of twigs and grass, to act as a levee bank. Often the whole construction is also thatched to prevent wind erosion.

Nest of mulga ant (*Polyrhachis macropa*)

Spiders

Sudden sheet flooding is also a hazard for desert spiders with underground nests. *Aganippi* (spiny trap door spiders) construct a well-fitting ‘bath-plug’ door, which they can pull down after entering to waterproof their underground nest.

One of the largest and most aggressive of spiders in the Australian desert is the hairy barking spider (*Selenocosmia stirlingi*), at least twelve centimetres across, which roams to forage but also builds a 'fishing-line' mesh around its open-holed burrow to ambush prey – insects, lizards or frogs. It takes its common name from a low growling noise it produces by rubbing its palms together. Yet this fearsome-looking spider is, in turn, a succulent prize for its predators, such as small carnivorous mammals like the dunnart, which rarely need to drink.

Hairy barking spider (*Selenocosmia stirlingi*)

Amphibians

For amphibians that spend at least part of their lifecycle in water, a desert environment presents particular difficulties. But there are some twenty species of water-retaining, burrowing frogs whose broad heads and short limbs with digging structures on the underside of their feet make them very efficient excavating machines. They can also literally absorb water from moist ground by flattening themselves out so that negative pressure between the cells of the ventral skin acts like blotting paper absorbing water. The water-holding frog (*Cyclorana platycephala*) survives in the arid zone by burrowing underground and remaining dormant during drought for up to five years. It can store a large volume of water in its bladder and also secretes an external cocoon of old dead skin that remains around its body like plastic wrap to reduce water loss. Its burrow is so deep that only heavy rainfall percolates down to wake the frogs up for breeding; but once that happens they emerge to eat, mate and lay eggs in temporary puddles. Some eggs may be attached to vegetation, ensuring an adequate oxygen supply (Cogger and Zweifel 1998). supply[8]. The development from egg to tadpole to frog is accelerated by voracious feeding (van Oosterzee 2000, 126–7), feeding[9], as the tadpoles have only a brief window of opportunity to metamorphose before the puddles evaporate.

Water-holding frog (*Cyclorana platycephala*)

Some other species that normally require a moist environment have survived by physiological adaptations. The tiny shield shrimp (*Triops*) can tolerate high levels of salinity. In puddles and lakes formed on claypans after heavy rain shield shrimps grow visibly from tough, resistant eggs to 1.5-centimetre shrimps in a race against time as the water rapidly evaporates. By the twelfth day, when the female shrimps are about three centimetres long, hundreds of tiny eggs form on their underbodies and are laid in the last remaining patch of damp soil. As the water turns to thick mud the adults die but the eggs remain dormant, for many years if necessary, awaiting the next rains.

When finding water is a problem, many animals develop alternative ways of living to help them keep cool and to use less water. Some never drink, but get their water from seeds (some seeds contain up to 50 per cent water), plants and other animals, such as the fleshy barking spider which is approximately 60 per cent water. Some animals rarely spend any time above ground. Amazingly, this is true of a species of frog, the tiny sandhill frog (*Arenophryne rotunda*) of Western Australia, which lives and breeds deep in sandhills. Whereas most Australian burrowing frogs burrow backwards, the Sandhill Frog uses its strong arms and small head to burrows headfirst. As the moisture level falls, the frog pairs avoid desiccation by digging down to where the sand remains moist, emerging at night to feed on the prolific ant population. Uniquely, these frogs have no

tadpole stage: instead, tiny adult frogs emerge directly from the eggs after ten weeks (Hero and Roberts 2004).

Reptiles

Central Australia has the greatest diversity of reptiles of any habitat in the world, with up to forty species coexisting per square kilometre. Lizards in particular, from the perentie monitor lizard to tiny skinks, have adapted to this continental climate as, being cold-blooded, they can tolerate a wide range of temperatures. Nevertheless, to avoid water loss, some lizards burrow, some climb, some take cover under rocks or grass hummocks, others seek open spaces. Lizards hunt all shifts around the clock and coexist in a particular area by rostering the time of day when they are active, the area they hunt in, and the kinds of prey they devour. Skinks (*Ctenotus*) have adapted perfectly to the spinifex ecosystem (van Oosterzee 2000, 112, 116), and can live in close proximity because of variable body size, use of habitat and the different times when they hunt.

Growing to more than two metres in length, the perentie (*Varanus giganteus*) is the fourth-largest living lizard (King and Green 1999). Living in and around rocky hills and outcrops across much of inland Australia, perenties shelter from the sun in large burrows, often with several entrances or escape tunnels. Not that the perentie has much to escape from. It has few natural enemies and, being one of the desert's top predators, it feeds on many different sorts of animals from large poisonous snakes to small marsupials, such as wallabies. The female perentie lays around six to ten eggs in termite mounds which, as noted above, provide a constant warm temperature. The brightly coloured young hatch around two to three months later.

Perentie monitor lizard (*Varanus giganteus*)

The fearsome-looking Australian thorny devil (*Moloch horridus*), studded with spines and tubercles, is actually harmless to all but the small black ants it devours at a rate of 5,000 a day. Its tough, spiked skin minimises evaporation and provides insulation, changing colour depending on the temperature. It has also evolved a unique means of acquiring water. Between the scales of its skin is a network of narrow grooves that channel moisture by capillary action from the soil to the corners of its mouth. In addition, the fierce-looking conical spines, fifteen centimetres long, are not just a deterrent to enemies but maximise the surface for condensation of vapour or dew. The resultant moisture is drawn along capillary-like channels to the mouth.

Thorny devil (*Moloch horridus*)

Geckos (such as *Nephrurus levis*) have evolved a different method to solve the water shortage. They effectively drink from their large, bulbous eyes, which have no eyelids but collect condensing dew on a transparent membrane. The gecko licks this clean by sweeping its long tongue across its face like a windscreen-wiper.

Knob-tailed gecko (*Nephruris levis*)

Mammals

Many Australian desert mammals shelter from the heat underground or in clumps of vegetation such as spinifex, feeding at dusk. The bilby, the mulgara or marsupial mouse, dunnarts and spinifex hopping mice are all crepuscular (dusk) feeders, as are red kangaroos and the rufous hare wallaby (*Lagorchestes hirsutus*). The greater bilby (*Macrotis lagotis*) excavates numerous tunnels within its home range and moves between these *pieds à terre* for shelter from predators and from heat. The bilby is wholly nocturnal, retiring to its solitary burrow an hour before sunrise and only emerging an hour after sunset to forage for seeds, grubs, fruit and insects.

Bilby (*Macrotis lagotis*)

Many of these animals have additional biological adaptations to conserve water and minimise temperature fluctuations. Dasyurids, Australian carnivorous marsupials comprising dunnarts (*Sminthopsis sp.*), the Pilbara ningaui (*Ningaui timealeyi*), and the mulgara (*Dasycercus cristicauda*), live mostly within clumps of spinifex. This particular plant, so prolific in the central deserts, shapes animal communities and fosters the survival of a wide variety of species. Its dome-shaped form and closely-packed leaves provide both food and shelter for a diverse array of insects, which, in turn, support the many reptiles, mammals and birds in the area. As we saw in 'Defying Drought: Desert Flora' spinifex stabilises shifting sand dunes, ``providing a safe area of compacted sand for burrowing animals. As well, because the plant holds still air within its folded, outwardly-projecting leaves, it minimises diurnal temperature fluctuations, providing a cool retreat in the heat of the day and holding warm air in the spaces at night when the ambient temperature drops significantly.

Dasyurids rarely need to drink because the insects, spiders, grasshoppers and small vertebrates they consume contain about 60 per cent water and they avoid heat stress by being nocturnal hunters and resting during the day. In times of plenty Dasyurids also store fat around their tail to be reabsorbed when needed. As the insects, which provide a large part of their diet, are plentiful throughout the year they can breed seasonally regardless of drought.

The northern marsupial mole, (*Notoryctes caurinus*) and the southern marsupial mole (*Notoryctes typhlops*) are the most enigmatic of Australia's desert animals. Ideally adapted for a subterranean life, they rarely emerge on the surface and are totally blind, their eyes being reduced to vestigial lenses under the skin. They are fast burrowers, using their nose pad and front feet to excavate sand, while their luxuriant fur helps reduce the friction of the sand. Their webbed hind feet drag sand behind them as they move forward, leaving distinctive 'collapsed tunnel' trails that may penetrate as much as 2.5 metres below the surface. Marsupial moles have no need to drink, as they meet their moisture needs from their diet of insects (mainly ants and termites) that they hunt beneath the surface, and occasionally seeds, spiders, lizards and fungi.

Drawing of the southern marsupial mole (*Notoryctes typhlops*)

The red kangaroo (*Macropus rufus*), Australia's largest surviving marsupial, is well adapted to aridity, saving energy as it leaps up to five metres in one bound. At high speeds, hopping on two legs is far more efficient than running on all fours because the Achilles tendon in each hind leg acts like a spring, recycling energy with every bound. A four-legged animal has to use more energy to go faster, but the kangaroo simply lengthens its stride while using the same hopping frequency. In addition, as it hops along, its diaphragm moves up and down without any muscular effort, emptying and refilling the lungs automatically. The kangaroo's reproductive system is similarly economical. In times of prolonged drought, the males become sterile and the female's reproductive system shuts down. In times of plenty, however, it becomes a highly efficient reproduction machine. Females produce up to three staggered offspring at any one time – a young joey hopping around out of the pouch, a smaller joey attached to a nipple in the pouch, and a tiny embryo. Females mate within days of giving birth but the new embryo will stop growing when about twenty-five millimetres long and remain in a

state of suspended animation until its next older sibling leaves the pouch. This embryonic diapause allows kangaroos to downsize their numbers in times of drought and increase them rapidly when food is available.

Fighting red kangaroos (*Macropus rufus)*

Because of their specialised adaptations, many desert animals are extremely vulnerable to introduced predators such as feral cats and foxes, and changes to their habitat caused by overstocking of cattle and camels. The mala, or rufous hare-wallaby (*Lagorchestes hirsutus*) is one such casualty. Once prolific in spinifex country throughout Central Australia, mala now survive in the wild only on a few small, predator-free islands off the Western Australian coast. Populations on the mainland exist only as captive colonies. The last two known wild populations in the Northern Territory were extinguished, as the result, in one case, of predation by a single fox, and in the other from a wildfire lit by people travelling the nearby Tanami Highway. This near-extinction is particularly distressing for the Western Desert Aṉangu people, for whom the Mala are important Ancestral beings who have watched over them and established the *Tjukurpa* or Law, which is central to their culture.

Mala or rufous hare-wallaby (*Lagorchestes hirsutus*)

Feral Mammals

In Australia, feral animals typically have few natural predators or fatal diseases and some have high reproductive rates if conditions are favourable. They have had a major impact on native species by predation, competition for food and shelter, by destroying habitat, and by spreading diseases to which native animals have no developed immunity.

The best known of all desert dwellers, dromedary camels have evolved a formidable range of adaptations enabling them to survive in extreme arid conditions. They conserve water by excreting very dry faeces in small cubes, and highly concentrated urine and their ability to survive an increase in body temperature to 45°C means they do not need to sweat to keep cool. They can lose up to 25% of their body weight through water loss and rehydrate rapidly when water is available. They can store fat in their hump to survive long periods without food. Long thick eyelashes and thick hair in their ears protect them from flying sand. Their nostrils fold flat to prevent moisture loss, and webbed skin between their toes prevents their sinking into the sand even when fully loaded.

Having been used successfully in desert exploration elsewhere, camels were imported to work in the semi-arid region of Australia in the nineteenth century. Intriguingly the first imported camels came not from the Middle East but from the Canary Islands. All but one died on the voyage and the surviving one, used by John Ainsworth Horrocks in an exploratory expedition in South Australia in 1846, was, as described in Chapter 12, the cause of Horrocks's accidental death. As well as horses, the Burke and Wills expedition of 1860 also used camels, imported from India. From the

1860s to 1900 some 15,000 camels, mostly dromedaries, were imported, mainly from India but also from Arabia and Afghanistan, for transport and heavy work in the outback. The Afghan cameleers exchanged knowledge with Aboriginal communities and Aboriginal men and women were employed as assistant cameleers on long desert treks (Koehler-Rollefson 2018).

When motorised transport replaced camels in the 1920s and '30s, many camels were released into the wild, giving rise to the largest population of feral camels in the world. By 2013 it was estimated to be 600,000, which culling reduced to 300,000, with a replacement rate of 10% per annum.[10] Now about 750,000 feral camels still roam wild in huge herds over more than 3.3 million square kilometres of the outback. Having soft pads on their feet, camels are not destructive of terrain except in disturbing the crests of dunes, but they ingest more than 80% of the plant species available, invade scarce water resources, foul waterholes and destroy pastoral and community structures (Wardrop 2009). structures[11].

Feral camels in the Simpson Desert

Being carnivorous, cats pose a far greater threat than camels to biodiversity in arid conditions. They endanger the survival of over 100 native species and have already caused the decline and extinction of many small and medium-sized mammals, including some species of hopping-mice, small rodents, the mala, bettong, bandicoot, bilby and numbat as well as several species of ground-dwelling birds. They also subvert attempts to reintroduce native species, such as the rufous hare-wallaby, to their natural habitat and they transmit infectious diseases to which native animals have no resistance. Control or elimination of feral cats is more difficult than it is for camels, as

cats eat a wide range of prey and produce large litters throughout their adult lives. So far, small-scale methods such as trapping, shooting and exclusion fencing have had limited effect in such vast, largely uninhabited areas (NSW Department of Planning, Industry and Environment 2019). areas[12].

Other introduced species that present a threat to the environment or to native animals are foxes, rabbits, feral deer, goats, wild horses (brumbies), feral pigs, and water buffalo (*ibid*., 2018) buffalo.[13] which cause immense damage to the environment through erosion, and threaten the habitat of native species.

Survival of small native animals in an already harsh landscape, is under severe threat from these imported populations, discarded and released by the settlers who introduced them.There are, however, some encouraging success stories. One species, the elusive, yellowish green night parrot (*Pezoporus occidentalis*) was missing for almost a century and thought too be extinct.But in September 2024 a research team of Indigenous rangers and scientists, using audio-recordings of the parrot's distinctive call, detected a population of 50 birds in the Great Sandy Desert of Western Australia and western Queensland. These ground-dwelling birds, which fly only when frightened or in search of water, are in danger from feral cats and loss of habitat by fire. Several programs are in train to manage country in hopes that they may be rescued from extinction.

Night Parrots. Illustration by Elizabeth Gould for John Gould's *Birds of Australia*, 8 volumes (1890)

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[1] Charles Darwin, *The Origin of Species*, p. 460.

[2] John Muir, *John of the Mountains: The Unpublished Journals of John Muir*, ed. Linnie Marsh Wolfe, Madison, WI: University of Wisconsin Press, 1979.

[3] The collision sent clouds of dust, soot and small rock particles into the air, that blocked sunlight from the Earth for months, See A.A. Chiarenza, A. Farnsworth, P.D. Mannin et al., 'Asteroid impact, not volcanism, caused the end-Cretaceous dinosaur extinction', *PNAS* 117 (29), 2020, 17084 – 17093.

[4] *Zaglossus hacketti* is a little known extinct species. Fossils have been found in Mammoth Cave, Western Australia. About 1 metre long and weighing about 30 kg, it was the largest known monotreme.

[6] Depending on the species, this is between 24° and 35°. Australian Museum (2019), 'Termites', <https://australianmuseum.net.au/learn/animals/insects/termites>, viewed 23 February 2022.

[7] Julia C. Jones and Benjamin P. Oldroyd, 'Nest Thermoregulation in Social Insects', pp. 153–192.

[8] Harold G. Cogger and Richard G. Zweifel, *Encyclopedia of Reptiles and Amphibians*.

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[13] For more detail see Australian Government Department of the Environment nd Energy, 2018. 'Feral Animals in Australia'. <https://www.environment.gov.au/biodiversity/invasive-species/feral-animals-australia>. Retrieved 23 February 2022.