The application of Zoos Victoria's 'Fighting Extinction' commitment to the conservation of Leadbeater's Possum *Gymnobelideus leadbeateri*

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Abstract
As part of its 'Fighting Extinction' program, Zoos Victoria has developed criteria to guide when it will initiate captive-breeding programs for native threatened species. Application of these criteria, which are based on extinction risk, has resulted in the identification of twenty priority threatened species for ex situ conservation. This list includes the genetically-distinct lowland population of Leadbeater's Possum. As a result, a captive-breeding program has been initiated to prevent the extinction of this population. The 'Fighting Extinction' strategy represents a more structured, systematic and integrated approach to how Zoos Victoria is attempting to deliver tangible conservation outcomes. Notably, measures of success are tied to the condition of wild populations. Aspects of the 'Fighting Extinction' strategy and the Leadbeater's Possum captive-breeding program are described. (*The Victorian Naturalist* **129** (5) 2012, 175-180)

Keywords: Leadbeater's Possum; captive-breeding; zoo; threatened species; extinction

In its 20-year strategic plan, Zoos Victoria has committed to transforming itself into a 'zoo-based conservation organisation' that delivers tangible conservation outcomes for wildlife populations. Considerable effort has gone into defining precisely what this means, and the strategy highlights that the organisation is not just concerned with the captive collection, but is very much focused on the condition of wild populations. In terms of delivering tangible outcomes, the conservation of native threatened species has been identified as a clear priority, and forms one of the central elements to a more holistic conservation approach that has been developed under the banner 'Fighting Extinction'. Part of this approach is outlined below.

'Fighting Extinction'

To create greater transparency around when we will initiate captive-breeding programs for native threatened species, the following commitment has been made:

> 'Zoos Victoria will ensure that no Victorian species of terrestrial vertebrate become extinct.'

The focus on terrestrial vertebrates reflects the expertise at Zoos Victoria's three properties, Melbourne Zoo, Werribee Open Range Zoo and Healesville Sanctuary.

In applying this criterion, Victorian species have been assessed and prioritized based on their likelihood of extinction in the wild over the next 10 years. These qualitative determinations focused on population size and trend, extent of distribution and key threatening processes. In addition to the eleven captive-breeding programs that Zoos Victoria already had in place for species occurring in south-eastern Australia (seven of which targeted Victorian species; see Table 1), this review identified nine additional Victorian species warranting *ex situ* recovery measures (Table 2), including Leadbeater's Possum *Gymnobelideus leadbeateri*. Hence, Zoos Victoria has arrived at a priority list of 20 native threatened species. This list will be reviewed periodically, and species added or removed as new data become available and/or circumstances in the wild change. Note that under these criteria, *ex situ* intervention is not triggered for species that are in decline within Victoria but have strongholds in other States or Territories.

Having a clear understanding of why we are focused on certain species and not others has created greater clarity in where Zoos Victoria invests resources. New captive programs have already been initiated for four of the nine species listed in Table 2. For these additional species, our approach first involves the establishment of captive populations, followed by subsequent releases to the wild to recover populations.

Three of Victoria's highest profile threatened species highlight the important role that zoos can play in conservation. The mainland Eastern Barred Bandicoot *Perameles gunnii* unnamed

Table 1. The 11 native threatened species included in Zoos Victoria's captive-breeding programs prior to 2011.

Common Name	Scientific Name	Conservation Status (EPBC Act)	Year commenced	Captive breeding	Reintroduction
Tasmanian Devil	*Sarcophilus harrisii*	Endangered	2006	✓	
Mountain Pygmy Possum	*Burramys parvus*	Endangered	2007	✓	
Eastern Barred Bandicoot (mainland)	*Perameles gunnii* unnamed subspp.	Endangered	1990	✓	✓
Orange-bellied Parrot	*Neophema chrysogaster*	Critically Endangered	1991	✓	✓
Helmeted Honeyeater	*Lichenostomus melanops cassidix*	Endangered	1989	✓	✓
Regent Honeyeater	*Anthochaera phrygia*	Endangered	2002	✓	
Spotted Tree Frog	*Litoria spenceri*	Endangered	2006	✓	✓
Southern Barred Frog	*Mixophyes balbus*	Vulnerable	2001	✓	
Southern Corroboree Frog	*Pseudophryne corroboree*	Endangered	2008	✓	✓
Northern Corroboree Frog	*Pseudophryne pengilleyi*	Vulnerable	2010	✓	✓
Lord Howe Island Stick Insect	*Dryococelus australis*	Critically Endangered	2003	✓	

Table 2. The nine additional Victorian threatened species identified as warranting *ex situ* intervention under Zoos Victoria's 'Fighting Extinction' commitment.

Common Name	Scientific Name	Conservation Status (EPBC Act)
Leadbeater's Possum (Yellingbo ESU)	*Gymnobelideus leadbeateri*	Endangered
Brush-tailed Rock-wallaby (Southern ESU)	*Petrogale penicillata*	Vulnerable
Smoky Mouse	*Pseudomys fumeus*	Endangered
New Holland Mouse	*Pseudomys novaehollandiae*	Vulnerable
Southern Bent-wing Bat	*Miniopterus schreibersii bassanii*	Critically Endangered
Grassland Earless Dragon	*Tympanocryptis pinguicolla*	Endangered
Alpine She-oak Skink	*Cyclodomorphus praealtus*	Endangered
Guthega Skink	*Liopholis guthega*	Endangered
Baw Baw Frog	*Philoria frosti*	Endangered

subspp. would be extinct if it were not for the breeding and release program undertaken by Melbourne Zoo. Similarly the Helmeted Honeyeater *Lichenostomus melanops cassidix* may be extinct if it were not for the breeding and release program undertaken by Healesville Sanctuary. And the Orange-bellied Parrot *Neophema chrysogaster* is predicted to go extinct in the wild during the next five years; however a large insurance population has been established in captivity. All the recovery potential for these Victorian species rests on successful captive-breeding and release programs. Conversely, each of these breeding programs has been in place for about 20 years and yet wild populations for each species remain at risk. Thus, some adjustments are required to the recovery models being applied.

In recognition of the need to increase the effectiveness of captive-breeding and release programs, Zoos Victoria has made several changes in how it is approaching threatened species recovery. We are working with recovery teams to achieve greater clarity and integration of the re-

covery targets for the wild and captive components to these programs. Too often in the past, the parties driving *in situ* and *ex situ* recovery measures have operated independently of one another. If the captive-breeding programs exist fundamentally to serve the wild, then ultimately they should be responsive to the recovery needs of the wild populations.

In order to minimise the loss of genetic diversity in captive populations, we are looking to manage our threatened species as part of captive–wild metapopulations. This involves periodic transfer of individuals between all populations, regardless of whether they are captive or wild, to maintain gene flow. This is already being done effectively for the Helmeted Honeyeater. We also recognise that the 'quality' of the individuals being bred in captivity has important implications for success when we come to release to the wild. This has become a major research focus for Zoos Victoria, and includes the application of techniques to promote mate choice and the retention of appropriate wild behaviours in captive populations.

Finally, the ultimate measure of success for our 'Fighting Extinction' programs is the condition of wild populations. Specific five-year and 20-year recovery objectives have been developed for each species in the wild and captivity, resulting in greater integration of *in situ* and *ex situ* approaches.

Leadbeater's Possum

Leadbeater's Possum is a small (110–160 g), arboreal marsupial that was thought to be extinct prior to its rediscovery near Marysville in 1961 (Wilkinson,1961). The possum is the only species of native mammal restricted in distribution entirely to Victoria, and its current range is confined to a 70 × 80 km area centred on montane habitats in the Victorian Central Highlands (see Harley 2004). A single, remnant, outlying population occurs in lowland habitats at Yellingbo Nature Conservation Reserve (Harley *et al.* 2005). Molecular data have revealed that the lowland population at Yellingbo is genetically distinct from populations occupying montane habitats (Hansen 2008; Hansen and Taylor 2008; Hansen *et al.* 2009). Owing to its restricted distribution, small population size (< 2000 individuals) and the loss of mature, hollow-bearing trees that provide dens, the species is currently listed as 'endangered' under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* and 'threatened' under the *Victorian Flora and Fauna Guarantee Act 1988*. Notably, the Black Saturday wildfires in 2009 burnt approximately 45% of the high quality habitat for the species (S. Smith, unpubl. data), greatly elevating the extinction risk for this species.

Zoos Victoria has assessed the extinction likelihood for Leadbeater's Possum populations in montane habitats and at Yellingbo against its 'Fighting Extinction' criteria (i.e. our trigger for captive intervention). The montane populations are in serious decline, particularly following the Black Saturday fires, and the extinction risk is very real over coming decades. However, the species is not likely to become extinct across the entire Central Highlands during the next 10 years, and hence they do not yet trigger *ex situ* intervention. Moreover, the key challenges in the Central Highlands are related to habitat conditions, and captive-breeding is not an appropriate tool to address this problem.

In contrast, the small, genetically-distinct lowland population at Yellingbo does meet Zoos Victoria's criteria for *ex situ* intervention, as a single fire could eliminate the entire population given its localized occurrence. Hence, this population is the focus of Zoos Victoria's captive-breeding and release program.

Population monitoring for the lowland Leadbeater's Possums at Yellingbo has been underway for 17 years (Harley 2005; Harley and Antrobus unpubl. data). Data describing the species' population dynamics at this site is the best available for any Victorian mammal (given it is a closed population and more than 90% of the total population is sampled every year). The annual monitoring program results in several measures of population condition, including total population size, distribution, territory stability, mean colony size, reproductive rate, annual recruitment and dispersal. The current size of the population is approximately 60 individuals, and it has declined by 46% during the past nine years (Harley and Antrobus, unpubl. data). Changes in the genetic characteristics of the population over the past 10 years are currently being assessed. The key threat to

this population is the serious decline in habitat conditions in the reserve, and as a consequence the availability of suitable foraging habitat has become the key limiting factor (Harley *et al.* 2005; Harley, unpubl. data).

Zoos Victoria has developed five-year and 20-year objectives for the recovery of Leadbeater's Possum in lowland habitats (covering both wild and captive populations). The five-year objectives developed for the wild emphasise the need to address habitat decline at Yellingbo, the key threatening process at this site. To achieve this, Zoos Victoria needs to work with partners such as Parks Victoria, highlighting the importance of integrating *in situ* and *ex situ* recovery measures.

In captivity, the five-year objectives are as follows:

1. Healesville Sanctuary and Melbourne Zoo house a viable captive insurance population comprising at least 20 individuals for the genetically-distinct lowland population of Leadbeater's Possum at Yellingbo.
2. Captive possums are managed to promote successful breeding and maintain wild behaviours.
3. Release techniques are developed to successfully establish captive-bred individuals in the wild.
4. Zoos Victoria provides unique opportunities for the public to engage with Leadbeater's Possum and its conservation.

The first four founders for the captive population were collected during May 2012 and are now housed at Healesville Sanctuary. The collection schedule for founders is four possums per year for three years. Collection has been staggered over time to minimise any negative impact on the wild population. Individuals are being selected based on their genetic attributes and to avoid disrupting colony structure (e.g. collection of dispersal-age subadults). The target size of the insurance population is 20–30 individuals, and this will be spread across two properties, Healesville Sanctuary and Melbourne Zoo. We intend to manage the insurance population as part of a captive–wild metapopulation, albeit this requires us to be able to successfully establish captive-bred young in the wild.

We are placing considerable emphasis on trying to maintain key wild behaviours in the captive possums, and this is being reflected in the types of animal monitoring we are undertaking (e.g. filming visitation to food stations and activity periods). We are using the behaviour exhibited by the wild-caught founders as a benchmark against which we can assess captive-bred young in future years.

Our ultimate goal is recovery of wild populations of Leadbeater's Possum in lowland habitats. The 20-year objectives for the wild define our vision of success, and are as follows:

1. Wild population size at Yellingbo exceeds 150 individuals.
2. Greater than 25% of the Cockatoo and Macclesfield Creek floodplains provide high quality habitat for Leadbeater's Possums.
3. Population and habitat monitoring programs maintained for Leadbeater's Possum at Yellingbo.
4. Establishment of at least one additional lowland population containing a minimum of 50 individuals.

Note that these objectives list a minimum population size for Yellingbo (≥150 individuals) that should be self-sustaining in terms of population processes. They also specify the area of habitat required to achieve this population target, and identify the need to establish additional lowland populations away from Yellingbo. The latter point highlights that success with this species ultimately means that we would no longer require an insurance population in captivity.

There are two key reasons why Zoos Victoria has directed its conservation efforts at the Yellingbo population of Leadbeater's Possum: (i) this population is at the greatest risk of extinction in the short-term (i.e. within 10 years), and (ii) the population is genetically distinct. In 2011, the Leadbeater's Possum Recovery Team debated whether conservation of the unique lowland genes at Yellingbo is of high importance. The consensus was it is important to protect them. Moreover, conservation of genetic diversity across a species' range is an important principle, and this has been reflected in the approach of the Victorian Government where several high-profile threatened species recovery programs target subspecies or genetically-distinct populations ('Evolutionarily Significant Units'), e.g. Red-tailed Black-Cock-

atoo, Helmeted Honeyeater, Eastern Barred Bandicoot, Brush-tailed Rock-wallaby, Mountain Pygmy Possum.

Action for the Yellingbo population of Leadbeater's Possum alone is clearly insufficient to adequately conserve this species. The species' stronghold is in the montane forests of the Victorian Central Highlands, and consequently the main conservation focus from government should be directed there. Greater recovery focus on the montane populations following the Black Saturday fires is clearly warranted. In applying a holistic conservation strategy for this species (that incorporates risk-spreading), recovery models (and actions) should be articulated for all three forest types that Leadbeater's Possum inhabits (i.e. montane ash forest, subalpine woodland and lowland swamp forest) that take account of the different threats and management issues.

Community Engagement

Melbourne Zoo, Werribee Open Range Zoo and Healesville Sanctuary attracted approximately 1.9 million visitors in 2011. A high proportion of this audience lives in urban environments, yet the majority of threatened species issues occur in regional areas. Zoos have a unique opportunity to bridge this gap, connect people with the issues and provide them with simple things they can do to assist. In recognition of this, Zoos Victoria has developed specific 'visitor objectives' to sit alongside our breeding and release targets. The 'Wipe for Wildlife' campaign at Healesville Sanctuary urging visitors to use recycled toilet paper to reduce the number of trees harvested is an example of this approach. Importantly, subsequent uptake among visitors is being measured. In association with the Leadbeater's Possum program we are promoting the use of Forest Stewardship Council (FSC) certified timber and paper products. These programs apply the Connect–Understand–Act model developed by Rachel Lowry, Zoos Victoria's Director of Wildlife Conservation & Science, to promote behaviour change amongst our visitors in ways that will benefit wildlife populations.

Zoos Victoria's 20 priority species are being promoted to the Victorian community under the banner 'Love you Locals'. And we are in the process of testing some different techniques to raise the profile of these species. Part of this involves a major campaign at Healesville Sanctuary that aims to get children to connect with Leadbeater's Possum through the creation of a cartoon character (Lunar) and an animated interactive display (Lunar's Secret Forest).

Conclusion

Several distinct changes are evident in how Zoos Victoria is currently tackling threatened species recovery through its 'Fighting Extinction' program. These include the following:

- criteria to guide when we will initiate captive-breeding programs for native species;
- closer integration between management of the wild and captive populations;
- measures of success that are tied to the condition of wild populations;
- establishment of captive–wild metapopulations to minimise the loss of genetic diversity and maintain appropriate behaviours;
- research programs directed at improving the quality of individuals bred in captivity;
- major focus on increasing community understanding and engagement with our threatened species programs. This includes use of the Connect–Understand–Act model to promote behaviour change in our visitors.

This strategy represents a more structured, systematic and integrated approach to how Zoos Victoria is attempting to deliver 'tangible' conservation outcomes.

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Forest Ecology – A Victorian Perspective

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Forest communities typically are defined by their floristic composition and structure. This data is collected using quadrat based surveys and analysed statistically using a nearest neighbour algorithm. Tens of thousands of such quadrats have been collected across Victoria and this data has been used to identify numerous vegetation communities known as ecological vegetation classes (EVCs). While EVCs are locally based on floristics they are more broadly defined by a consistent set of physical and climatic parameters such as rainfall, aspect and soil conditions. Wet Forest in East Gippsland therefore may have quite different floristics from those in the Otway Ranges, but as they occur under similar environmental conditions, support similar lifeforms and have similar structural characteristics they are identified as the same EVC.

The composition and structure of a forest community is also governed by the type, intensity and frequency of disturbance (i.e. fire, frost, disease, wind throw, landslide, timber harvest). Plants recover from disturbance using one or a combination of two strategies including resprouting from an organ (i.e. lignotuber, epicormic shoots, rhizomes etc.), which survives the disturbance, or establishing a new individual from seed or spore. The individual life history strategies of species therefore govern their ability to persist in different ecosystems under different disturbance regimes.

Forests are often described in terms of their age, with conservation efforts often focused on the concept of 'old growth'. This tends to concentrate on the age and structure of the overstorey and time since disturbance. However, studies on the age of different understorey species indicates that some have individuals, if not populations, which are older, sometimes significantly so, than the overstorey. Carbon dating results from common, often dominant, understorey species collected from Victoria's Central Highlands Wet Forest include Soft Tree-fern *Dicksonia antartica* (5.3 m tall 350 ±50 years), Rough Tree-fern *Cyathea australis* (12.5 m tall 370 ±70 years), Musk Daisy-bush *Olearia argophylla* (~100 years from within 1939 regrowth Mountain Ash *Eucalyptus regnans*) and Tree Geebung *Persoonia arborea* (12 m tall 320–510 years).

These 'old growth' understorey components are often resprouters and can be very influential in both the ongoing structure and composition of the forest and the post-disturbance recovery process. However, where the disturbance is more physical, such as that associated with timber harvesting, these resprouters often fare very poorly in the post disturbance recovery process in comparison to their survivorship after fire. Such changes undoubtedly have ecological consequences for forest regeneration.