Koalas and Kangaroos: Managing Australia's Charismatic Icons on the World's Stage

Catherine A. Herbert
Koala and Kangaroo Contraception Program, School of Biological, Earth & Environmental Sciences, University of New South Wales, Sydney, Australia

ABSTRACT: The management of overabundant native mammals is a contentious issue. In Australia, this is exemplified by the management of kangaroos and koalas. The iconic status of these species, nationally and internationally, greatly influences the perception of acceptable wildlife management practices. Lethal control techniques now face widespread opposition. This has resulted in research and development of alternative management strategies, with emphasis on potential fertility control agents. Australian Research Council Funding in 2005 supported the formation of a new initiative: The Koala and Kangaroo Contraception Program. Over the last 7 years, our research group has been testing the effects of a long-acting contraceptive implant (Suprelorin®, Peptech Animal Health), containing the gonadotropin-releasing hormone (GnRH) agonist deslorelin, on kangaroos and koalas. Within the last year, we have commenced large-scale field trials on two species: koalas on Kangaroo Island, South Australia; and tammar wallabies on the Abrolhos Islands, Western Australia. These field trials aim to evaluate the efficacy of using long-acting contraception to control marsupial populations and will measure the effects of contraception at the individual, population, and environmental level. This is paralleled by development of a remote delivery system that will greatly enhance the efficacy of this form of population management.

KEY WORDS: Australia, contraception, deslorelin, fertility control, GnRH agonist, grey kangaroo, koala, *Macropus* spp., marsupial, *Phascolarctos cinereus*, reproduction, tammar wallaby

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INTRODUCTION

Since the onset of European settlement in Australia, marsupial populations have fluctuated greatly. The combined impacts of habitat clearance and fragmentation; introduction of exotic predators, competitors, and diseases; altered fire and land management regimes; and hunting have generally worked to cause a reduction in the range and status of many indigenous marsupial species (Maxwell *et al*. 1996). However, at the other end of the scale are some marsupial populations that are considered overabundant at a local or regional level. In some cases these species are classed as secure throughout their range (e.g., the large kangaroo species), while in other cases there are geographic and temporal variations in status (e.g., koalas and some small wallaby species).

The management of overabundant marsupial populations in Australia presents wildlife managers with numerous challenges. The prevailing socio-political climate is such that lethal control techniques are often deemed unacceptable for these populations (Adderton Herbert 2004), particularly in the case of koalas (*Phascolarctos cinereus*). This has resulted in research and development of alternative ways to control populations by reducing the fertility of animals within the population (fertility control).

The aims of this paper are to 1) summarise the factors associated with burgeoning marsupial populations, 2) discuss the challenges of managing overabundant marsupials in Australia, 3) outline the effects of a new long-acting contraceptive implant (Suprelorin®) on marsupials, and 4) introduce a new research project: The Koala and Kangaroo Contraception Program (KKCP).

OVERABUNDANT MARSUPIAL POPULATIONS

When discussing overabundant populations, it is important to remember that the term "overabundant" cannot be clearly defined by biological parameters. It is a value-laden term that means different things to different people. As such, the factors that contribute to overabundant populations may be tangible (e.g., alterations to the environment) or intangible (e.g., people's perceptions, which may vary over time). In general, the factors influencing marsupial overabundance include:

1. Isolation of populations by habitat fragmentation/ fencing
2. Success of conservation programs, e.g., wallabies in WA, koalas
3. Removal/control of predators
4. Supply of additional environmental resources
5. Changing perceptions/attitudes
6. Conflict with humans – marsupials may only become viewed as overabundant (i.e., there is the impetus to actively manage them) when they are at odds with humans (e.g., land usage, damage to crops)

The relative importance of these six factors, as they pertain to kangaroos, wallabies and koalas, are briefly discussed below, along with the management challenges for each of these taxa.

Kangaroos

European settlement has generally had a negative impact on the smaller macropodids, with severe range constrictions and/or extinction of species not uncommon (Maxwell *et al*. 1996). But the larger kangaroo species,

including the red kangaroo (*Macropus rufus*) and eastern and western grey kangaroos (*M. giganteus* and *M. fuliginosus*, respectively), are widespread across Australia and appear to have flourished. These species are believed to have increased in number and range since European settlement, as a result of protection from predation by the "dingo fence" and provision of watering points and improved pasture associated with agriculture (Pople and Grigg 1999).

When large kangaroo populations conflict with agricultural ventures in rural areas, the state government wildlife management agencies will grant permits that allow for the destruction of kangaroos under a strict quota system, based on annual population estimations (Pople and Grigg 1999). Culling of these kangaroos must conform to the Code of Practice for the Humane Destruction of Kangaroos (Anon. 1994), which states that kangaroos must be shot to "ensure a sudden and painless death for target animals".

Kangaroos can also reach high population densities in nature reserves and urban areas. In many instances, these populations are deliberately or inadvertently confined, so that the growing population has no where to disperse (for review see Coulson 1998, Adderton Herbert 2004). The use of culling to control populations in these areas receives very little public support. In addition, the use of high-velocity projectiles to humanely kill kangaroos via culling would pose a serious human safety issue near urban areas. As such, there has been increasing interest in the use of fertility control to manage urban kangaroo populations (Nave *et al*. 2002*b*; Herbert *et al*. 2004, 2005, 2006). A good example of this is the management of kangaroos on a housing development site in Western Sydney. Approximately 600 ha of the 1,545-ha site, containing 2,275 - 3,200 eastern grey and 248 - 448 red kangaroos, is scheduled for development over the next decade. The kangaroo density needs to be reduced to account for the progressive loss of habitat, particularly feeding areas, as the development progresses and to ensure kangaroos do not damage a threatened ecological community on the site. Culling was initially proposed to reduce the population (ERM 2003), but widespread public and political opposition has resulted in the development of an adaptive management plan focusing predominantly on the use of fertility control to reduce the population density. Fertility control will involve both contraception (Suprelroin® implants, discussed in more detail below) and surgical sterilization (tubal ligation or ovariectomy) of females (Cumberland Ecology 2004). The location of this and other peri-urban sites with overabundant kangaroo populations is shown in Figure 1, with accompanying locations noted in Table 1.

Wallabies

Over the last decade, a new marsupial management challenge has emerged– the management of macropod populations recovering after the reduction of introduced predators. Western Australia (W.A.) has made a significant investment in fox control undertaken as part of program "Western Shield" (Mawson 2004). As such, W.A. finds itself in the unparalleled situation of potentially having to manage high-density populations of marsupials that were only recently classified as threatened, for example, tammar wallabies (*M. eugenii*), woylies (*Bettongia penicillata ogilbyi*), and black-flanked rock-wallabies (*Petrogale lateralis*) (Orell 2004). Woylies and tammar wallabies were de-listed from the IUCN threat categories and down-graded to Lower Risk (near threatened) in 1996 and 1998 respectively (Mawson 2004).

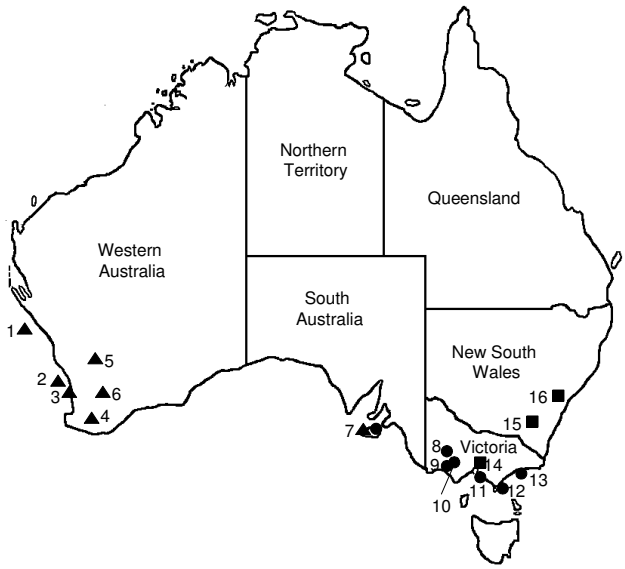

Figure 1. The location of some overabundant marsupial populations in Australia: circle, koala populations; square, kangaroo populations; triangle, wallaby populations. Details of the specific populations can be found in Table 1. The populations presented are those where fertility control technology may be relevant to management.

Table 1. Location of marsupial populations presented in Figure 1.

Wallabies	Koalas	Kangaroos
1. North Is.[A]	7. Kangaroo Is.	14. Outer Melbourne
2. Rottnest Is.[B]	8. Tower Hill Wildlife Reserve	15. Canberra (ACT)
3. Garden Is.[A]	9. Mt Eccles NP	16. St Marys
4. Perup Forest[A]	10. Framlingham	
5. Mt. Caroline NR[C]	11. French Is. NP	
6. Tutanning NR[A]	12. Snake Is.	
7. Kangaroo Is.[A]	13. Raymond Is.	

[A] tammar wallaby, [B] quokka, [C] black-flanked rock wallaby

The dramatic increase in population size and range of various wallaby species has created some issues of overabundance at a local scale. For example, tammar wallaby populations at Tutanning Nature Reserve and Perup Forest (for locations see Figure 1, Table 1) have increased dramatically, causing damage to cereal crops on adjacent land (Mawson 2004). Wide-scale habitat fragmentation in these areas means that the increasing populations are unable to disperse without human assistance. The current management technique is to trap animals and reintroduce them to other areas within their

former range (where there are not conflicting land-use values), which also has conservation benefits (Mawson 2004). Given that these species have only recently started recovering and their long-term viability can not be guaranteed, translocation is a sound management option. Culling these animals would not send the right message to landholders regarding the conservation value of these species. Another appropriate management strategy for these populations would involve applying a reversible fertility control agent. This would mean that the long-term viability of these populations could be safeguarded in the event of long-term environmental perturbations. It is also a method of population control which will retain the greatest amount of genetic diversity (compared with methods such as surgical sterilization and culling), as you do not need to treat the same animals every time, so that most individuals will get the opportunity to breed at some stage during their life.

Koalas

In the early part of the 20th century, koalas became extinct in South Australia and had declined severely in Victoria, NSW, and Queensland, primarily as a result of land clearing and the combined influences of hunting, disease, fire, and drought (ANZECC, 1998). This resulted in the enactment of protective legislation and the establishment of island colonies. Following dramatic population growth on many islands, these populations were used as a source to repopulate areas of the mainland. The extraordinary success of reintroduction programs has effectively restored koala populations to all areas of suitable habitat in Victoria, and these re-established populations are now deemed overabundant in many cases (Menkhorst *et al*. 1998).

The majority of overabundant koala populations occur in Victoria, with the exception of Kangaroo Island (South Australia), where koalas was introduced in 1923 (Masters *et al.* 2004). It is difficult to determine the suite of factors that have contributed to the dramatic increase in koala population densities in Victoria and Kangaroo Island. What is known is that sites where koalas have reached high densities resulting in over-browsing are typically characterised by 1) their isolation, 2) vegetation that is dominated by coastal manna gum (*Eucalyptus viminalis* subsp. *pryoriana* or *cygnetensis*), and 3) having only one or two preferred tree species for feeding (DSE 2004).

Management of overabundant koala populations has been particularly contentious over the last decade. Some factions, including environmentalists and some scientists, believe that these populations should be controlled by lethal means, so that other species within the ecosystem can benefit from reduced koala densities (for example, see Turner 2004). Others, such as the Australian Koala Foundation, believe that the koala is a species in peril, with its continued survival in jeopardy (Maxwell *et al.* 1996). The debate about koala management receives world-wide attention (see a sample list of publicity in Table 2), with many believing that negative publicity has the capacity to directly influence tourism income. The value of koalas for tourism was estimated at AUD$1.1 billion almost one decade ago (Hundloe and Hamilton 1997). This potential earning capacity, along with national and international social pressure, has the capacity to influence decisions in the political arena, with flow-on effects to state government wildlife agencies. State and federal politicians have categorically ruled out the possibility of culling koalas to reduce population densities (ANZECC 1998).

CONTRACEPTION USING DESLORELIN

Having clearly established the need for alternative management strategies to reduce overabundant marsupial populations, numerous groups have investigated the use of different fertility control technologies. Most work has involved either surgical sterilization (e.g., koalas, Duka and Masters 2005) or the use of long-acting contraceptive implants. The long-acting contraceptive implants that have been tested include the synthetic progestins, e.g.,

Table 2. News headlines associated with koala management issues, highlighting the contentious nature of koala management.

Headline/*Quote*	Date	Source
20,000 Koalas Face Slaughter	31 Oct 2001	BBC News (2001)
Koala Wars	11 Apr 2002	Catalyst (2002)
Call Continues for Kangaroo Is. Koala Cull "*Japan in particular, the media there goes absolutely berko every time this issue is raised and we rely a lot on the international market for our tourists*…" – Minister John Hill	1 Mar 2004	ABC News Online (2004)
Koala Cull: The Kangaroo Is. Controversy	15 Apr 2004	A Current Affair (2004)
Koala Cull Call Sees MP Blitzed with Hate Mail	10 May 2004	The Sydney Morning Herald (2004)
Koala Cull Would Be Public Relations Disaster: Minister "*The last time [there were calls for a cull], three media crews came over from Japan to follow it*" – Minister John Hill	18 Feb 2005	ABC News Online (2005*a*)
Mayor Rejects Koala 'Killing Ground' Claims "…*I received an email from someone in England on Friday calling me the Adolf Hitler of Kangaroo Island wildlife*…" – Michael Pengilly	8 Mar 2005	ABC News Online (2005*b*)
Foundation Casts Doubt Over Kangaroo Island Koala Numbers "*I think koalas are being demonized and have been for many years*" – Deborah Tabart	25 Apr 2005	ABC News Online (2005*c*)
8,000 Kangaroo Is Koalas Face Sterilisation	23 May 2005	ABC News Online (2005*d*)

Note: All are headlines, with the exception of phrases in italics and quotation marks, which were quotes from within the news article.

Table 3. Time from deslorelin or placebo implant administration to the first birth observed in tammar wallabies, eastern grey kangaroos, and koalas.

Species	Group	Time to 1st Birth	Reference
Tammar wallaby	Placebo	159 ± 47 days (*n* = 8)	Herbert *et al.* 2005
	5 mg deslorelin	516 ± 86 days (*n* = 7)	
Eastern grey kangaroo	Placebo	70 ± 10 days (*n* = 9)	Woodward *et al.* 2006
	10 mg deslorelin	510, 637, 642, >645 days (*n* = 10)	
Koalas	Placebo	97 - 202 days (*n* = 4)	Herbert 2002, unpublished data
	5 mg deslorelin	>431 days (*n* = 6) (Range >431 - 771)	

Note: values are means ± s.e. or ranges. The use of the 'greater than' sign (>) indicates that animals had not resumed breeding at the end of the experiment.

koalas (Middleton *et al*. 2003), tammar wallabies (Nave *et al*. 2000, 2002*b*) and eastern grey kangaroos (Nave *et al*. 2002*a*); and the GnRH agonist deslorelin, e.g. tammar wallabies (Herbert *et al*. 2004) and eastern grey kangaroos (Herbert *et al*. 2006). This paper will now focus on the work being conducted on deslorelin contraception.

Deslorelin is a GnRH agonist which has been formulated into slow release implants (Suprelorin®, Peptech Animal Health, Macquarie Park, NSW, Australia) releasing deslorelin over approximately 1 year. This implant is now registered as a veterinary product in Australia and New Zealand. These contraceptive implants work by inhibiting the production of luteinizing hormone (LH) and follicle-stimulating hormone (FSH), thereby inhibiting follicular development, ovulation and the production of gonadal steroids (Fraser 1993). Trials on tammar wallabies, eastern grey kangaroos, and koalas indicate that these implants can inhibit reproduction for periods of approximately 18 months (Table 3).

Intensive trials have been conducted on a model marsupial species, the tammar wallaby, to determine the contraceptive mechanisms of action in marsupials. This work has determined that deslorelin contraception inhibits follicular development, estrus, and ovulation (Herbert *et al*. 2004). Inhibition of ovulation means that there is no formation of an active corpus luteum, resulting in a reduction of progesterone concentrations to basal levels (Herbert *et al*. 2005). The pituitary is desensitized to endogenous GnRH, resulting in a reduction of LH concentrations (Herbert 2002). These physiological responses to deslorelin treatment result in successful contraception of female marsupials. Additional trials have also been conducted to determine the safety of deslorelin contraception if administered to females in different physiological states. Treatment of lactating females has no effect on the continued production of milk and the growth and development of the young proceeds at the same rate as control animals (Herbert, unpubl. data). Similarly, treatment of immature females (age 180-200 days) has no effect on their growth rate but delays the onset of puberty (Herbert, unpubl. data). Repeat treatment of females has no negative effects (Herbert *et al*. 2006).

Now that these preliminary investigations have been conducted intensively on a model marsupial species, and smaller-scale trials have been conducted on the target species (eastern grey kangaroos and koalas), the challenge lies in moving from the level of treating individual animals to treating entire populations. This is to be the focus of a new research program– The Koala and Kangaroo Contraception Program (KKCP).

The Koala and Kangaroo Contraception Program (KKCP)

The KKCP involves a group of scientists and wildlife managers with an interest in the management of overabundant koala, kangaroo and wallaby populations using fertility control techniques. The principle aims of the program are to make the use of fertility control more efficacious for administrations to animals in the field and to conduct large-scale field trials. This program focuses on the use Suprelorin® contraceptive implants, but the results have broader relevance to the fertility control field. The specific aims of this program are to:

1) Develop efficient means of delivering Suprelorin® long-acting contraceptive implants to animals in the field, and
2) To conduct large-scale fertility control trials on model marsupial populations to answer these questions:
   a) What are the effects of Suprelorin® on individual animals within different populations (e.g., reproduction, health, behaviour, and home-range)?
   b) Can population size be reduced by administering Suprelorin® to a certain proportion of females in the field?
   c) If fertility control successfully reduces the population size, is this translated into an improvement in the health of the environment (e.g., recovery of vegetation subject to browse damage)?

These 'model' marsupial populations will be representative of populations that cannot be controlled by other traditional population control techniques, such as culling and translocation. This program has been funded by the Australian Research Council from 2005-2009 under the Linkage grant scheme. The first trials have been initiated on tammar wallabies on North Island, within the Houtman Abrolhos Archipelago, W.A., and on koalas on Kangaroo Island (shown in Figure 1). Additional studies are planned for koalas on French and Raymond Islands, Victoria; quokkas on Rottnest Island, W.A.; and western grey kangaroos around Perth.

It is hoped that trials like the ones listed above will help fertility control move from the theoretical to the practical realm, supplying wildlife managers with much needed solutions to challenging management issues.

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