

The welfare ethics of the commercial killing of free-ranging kangaroos: an evaluation of the benefits and costs of the industry

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Abstract

The commercial killing of kangaroos provides multiple benefits to society, but also causes both deliberate and unintended harms to kangaroos. The ethics of the kangaroo industry is assessed in terms of whether the assumed benefits justify the welfare costs. An analysis of the stated benefits indicates that killing for damage mitigation is beneficial mainly during drought and not at current levels; that there is a commercial value, although considerably lower than previously estimated, and that demonstrable environmental benefits from commercial killing of kangaroos are lacking; and that the commercial kill may ameliorate the suffering of kangaroos during drought. Welfare practices are very difficult to assess and regulate due to the size and remote nature of the industry. A combination of empirical data on welfare outcomes and inferences drawn from behavioural and reproductive knowledge of the commercially killed species are utilised to assess harm. The welfare costs include deliberate and indirect harm to dependent young (a by-product of the commercial kill), and a number of unintended harms to adult kangaroos, including increased mortality during drought, inhumane killing of a portion of adult kangaroos, and a disruption of social stability and the evolutionary potential of individuals. Furthermore, a substantial gap exists between the intended welfare standards of the code of practice governing the kangaroo industry and the welfare outcomes for both dependent young and adult kangaroos. We found that, on balance, the benefits are lower than expected and the welfare costs are likely to be considerably higher than acceptable. More research, particularly at the point of kill, is necessary to verify and assess the extent of harms. A number of improvements are suggested to the code of practice to improve welfare outcomes.

Keywords: animal welfare, commercial, ethics, harvest, industry, kangaroo

Introduction

Considerable interest has arisen regarding the impact of humans on wild animal welfare (Littin & Mellor 2005; Bekoff 2010; Fraser 2010) including wildlife considered pests (Littin 2010; Mathews 2010) or resources (Gill 2000; Boom & Ben-Ami 2011). High profile examples, such as white-tailed deer (*Odocoileus virginianus*) in the US (Messmer *et al* 1997) and Canadian harp seals (*Phoca groenlandica*) (Daoust *et al* 2002) illustrate that community opposition to the killing of wildlife, whether it is perceived as pest or resource, can be strong. Ethical frameworks for assessing human impacts on animal welfare must expand to incorporate a broader range of possible harms to free-living animals (Fraser & MacRae 2011). Furthermore, when determining whether a particular human activity that causes animal suffering is necessary, it has been argued that both the purpose and means of the activity should be legitimate (Sankoff & Steven 2009). It is necessary for there to be some reason for the relevant activity, and that reason must conform to societal values

(Francione 2000; Weldon 2008). Even if there is a legitimate purpose to cause harm to animals, the suffering imposed by such activity may not be justified by the means utilised, particularly if there are less harmful procedures available at a comparable cost (Sankoff & Steven 2009).

Over the past 30 years in Australia, an annual average of approximately three million free-ranging kangaroos are commercially killed and processed annually by the kangaroo industry (not including young which are collateral deaths). They are killed in prescribed numbers ostensibly to manage their impacts on agricultural production, and for meat for human consumption and pet meat, and for hides and other products (Lunney 2010; Boom *et al* 2012). In 1998, the latest Australian congressional review of the use of wildlife, including the commercial killing of kangaroos, determined that although the commercial industry effectively “institutionalised the suffering of kangaroos”, the commercial killing is necessary due to the impact of kangaroos on farming income (Senate Rural and Regional Affairs and Transport Committee 1998). However, accumulating data do not show

Table 1 Acceptable shooting and euthanasia methods as prescribed by the *Code of Practice for the Humane Shooting of Kangaroos and Wallabies* (Sections 2.4 and 5.1 of the Code; DSEWPac 2012).

Description	Acceptable euthanasia method
Small furless pouch young (fits within the palm of the hand)	Single forceful blow to the base of the skull sufficient to destroy the functional capacity of the brain or Stunning, immediately followed by decapitation by rapidly severing the head from the body with a sharp blade
All furred young	Single forceful blow to the base of the skull, sufficient to destroy the functional capacity of the brain
Young-at-foot	Single shot to the brain or heart where it can be delivered accurately and in safety using the firearms and ammunition specified in Part A or B of Schedule 1
Adults	A shooter must aim so as to hit the target kangaroo or wallaby in the brain (see Schedule 2) and A shooter must not aim so as to hit the target kangaroo or wallaby in any other part of the body than that specified above

a correlation between the industry and agricultural damage mitigation outcomes and, in some quarters, the welfare costs are perceived to be too high (Boom & Ben-Ami 2011).

The kangaroo industry targets four of the largest species of kangaroo which are killed on the mainland (excluding Tasmania): red kangaroo (*Macropus rufus*), eastern grey kangaroo (*M. giganteus*), western grey kangaroo (*M. fuliginosus*) and common wallaroo (*M. robustus*). Their ranges include many parts of Australia's arid and semi-arid sheep rangelands occupying about 40% of the continent (Grigg 2002). In Tasmania, the commercial kill is primarily for skins and includes Bennett's wallaby (*M. rufogriseus*) and Tasmanian pademelon (*Thylogale billardierii*). Free-ranging wild kangaroos are shot by licensed shooters and partially eviscerated in the field. Carcasses are then brought to cold storage containers (chillers) for holding until they are sent to meat processing plants. Although management programmes are set by individual states, the conditions set out in the *National Code of Practice for the Humane Shooting of Kangaroos for Commercial Purposes* (the Code) provide the national standards for kangaroo welfare in the commercial industry (DSEWPac 2012) (Table 1).

This paper seeks to evaluate the ethics of the commercial killing of kangaroos by expanding the traditional view of animal welfare which looks at the deliberate harm caused to wild animals to include an assessment of the indirect harm to wild animals through disruption of natural processes (Fraser & MacRae 2011).

We achieve the ethical evaluation through a set of inquiries into the impact of the kangaroo industry on its components. We utilise a cost-benefit approach to assess the industry's impact on kangaroos compared against its purported benefits for people, livestock, the environment and wildlife (including kangaroos), and seek to provide a way forward that acknowledges non-wildlife needs and minimises harm

to wildlife (Sankoff & Steven 2009). Specifically, we ask: i) what are the benefits derived (for humans, the environment and kangaroos) from the industry; ii) what is the harm (welfare cost) for kangaroos; and iii) whether there are alternative methods that cause less harm to kangaroos.

We define animal welfare according to the broader definition of animal welfare provided by the Australian Animal Welfare Strategy, in which welfare means how the animal is coping with the conditions it is living in and sentience is the reason why welfare matters (Anon 2011); when the pain and distress suffered by animals cannot be easily evaluated it is necessary to "assume that animals experience these in a manner similar to humans unless there is evidence to the contrary" (National Health and Medical Research Council 2004); and the impact of social dynamics on the evolutionary potential of individuals and the persistence of populations (Storz 1999; East *et al* 2009), which recognises the longer lasting effects of human actions on the welfare of wildlife as opposed to farmed animals (Anon 2010a). Collateral death caused deliberately or indirectly by the kangaroo industry to dependent young (which are not utilised as a commercial product) is also considered a welfare issue.

Benefits arising from the commercial killing of kangaroos

Damage mitigation on agricultural and pastoral land

Primary motivations for managing kangaroo populations stem from the historical perceptions of kangaroos and their perceived impact on farmers' (crop production) and graziers' (livestock production) incomes. A series of reports have attempted to quantify the commercial impact of kangaroos on farmers and graziers (Young 1984; Gibson & Young 1987; Sloane Cook and King Pty Ltd 1988; McLeod 2004), reaching estimates of up to (Australian dollars used throughout) \$200 million (M) to graziers (Sloane Cook and King Pty Ltd 1988). Furthermore, ecologists have traditionally speculated that kangaroo numbers have increased since European settlement

due to the increased availability of watering points (Calaby & Grigg 1989; Fensham & Fairfax 2008) and land use conversions of forest to pasture (Calaby & Grigg 1989).

In contrast, recent government-commissioned reviews of the relationship between kangaroos and their environment concluded that no correlation has been established between commercial kangaroo killing and pastoral damage mitigation (see Olsen & Low 2006; Herbert & Elzer 2011). Furthermore, studies that have shown that competition with livestock for food typically occurs only during drought (Edwards *et al* 1995, 1996; Dawson & Ellis 1996). These findings have led to a dramatic revision of the cost of kangaroos to graziers, from a previous \$200M to \$15.5M (McLeod 2004). In this latest estimate the total cost of \$44.1M (to graziers and crop farmers) also includes a cost to crop farmers estimated at \$11.9M and fencing damage across all agricultural sectors estimated at \$16.7M. More recently, artificial watering points in the arid interior of Australia have been found to have little impact on the distribution and densities of kangaroos (Montague-Drake & Croft 2004; Croft *et al* 2007; Fukuda *et al* 2010; Letnic & Crowther 2012); Croft (2005) suggests that many artificial watering points in arid areas where kangaroo densities are high are located in areas in which water was historically accessible to kangaroos either above or right below the ground surface in ephemeral creeks.

The lack of correlation between the commercial kill and agricultural damage mitigation has led to some state-based policy changes regarding the management of kangaroos. Three out of four state kangaroo management programmes have revised their management aims from the killing of kangaroos as a pest management strategy to supporting a sustainable resource industry (Department for Environment and Heritage 2007; Department of Environment and Climate Change 2007; Environment and Resource Management 2007). Although the damage mitigation benefit to agricultural properties is questionable, and certainly much less than previously believed, kangaroos are still considered to be pests to graziers and crop farmers.

Commercial value

According to the Kangaroo Industry Strategic Plan 2005–2010, in 2005 the industry's estimated worth was \$200M employing some 4,000 people and projected to reach \$270M by 2010 (Kelly 2005). These jobs include primarily the shooters, and the workers in the meat processing plants.

The industry, however, has not generated consistent returns. Exports, the key revenue generating sector of the industry, have fluctuated from \$56M in 2003 to \$46M the following year and \$77M in 2007 (Foster 2009), and since then export values have declined to below \$30M in 2009 (ABARE 2010). The large fluctuations are precipitated by both climatic conditions and relations with trade partners. Rainfall is a key determinant of kangaroo populations (Caughley *et al* 1987) and too much of it can prevent shooters from reaching kangaroos in the field; in recent years Australia has been through recent extreme weather events of both El Nino during 2009–2010 (BOM 2012a)

and La Nina 2010–2011 (BOM 2012b). In addition, the export market was dependent on one nation, Russia, for 74% of revenue (Foster 2009). At the time of writing, Russia has ceased kangaroo meat imports due to concerns over hygiene (Anon 2010b; pp 20–22).

Environmental restoration

Land clearance and livestock grazing in Australia have caused land degradation (Landsberg *et al* 1999) and biodiversity loss (Fisher *et al* 2003). In addition, concerns about climate change have highlighted the high levels of greenhouse gas emissions produced by Australia's numerous livestock (Garnaut 2007). Kangaroos have a much lighter impact on the environment than sheep and emit about a quarter of the methane. Therefore, at least partial replacement of livestock with free-ranging kangaroos on pastoral properties by graziers is being promoted as a mitigation mechanism for these environmental issues in Australia (Grigg 1989; Ampt & Baumber 2006; Wilson & Edwards 2008; Cooney *et al* 2009).

However, the fact that kangaroos are shot at night, the lack of management rights over kangaroos and the low returns from kangaroos have been prohibitive to the involvement of graziers (Grigg 2002; Chapman 2003; Cooney *et al* 2009). Currently, most kangaroos are shot by licensed independent shooters and do not replace sheep in the landscape or provide incentive for improving land management on the farm; as such, the graziers' only perceived benefit is that of the removal of pests (Grigg 2002; Chapman 2003; Thomsen & Davies 2007; Baumber *et al* 2009). Furthermore, some ecologists question the feasibility and environmental merits of partial sheep replacement (McCallum 1995; Croft 2000; Russel 2008; Ben-Ami *et al* 2010). Nevertheless, if partial replacement or more direct benefits to graziers do not occur then commercial killing will continue to occur alongside the traditional livestock industry without this putative environmental gain, and with the risks associated with exploiting native wildlife.

Improved welfare outcomes

Literature that documents welfare issues in the kangaroo industry is varied in its assessment of the severity and type of welfare concerns, to the point of being contradictory. At one end of the spectrum there are assertions that not managing kangaroo populations has negative welfare ramifications. A drought-induced increase in grazing pressure on the rangelands can cause resident herbivores to become nutritionally deprived (Grigg 1997). However, extreme climatic conditions are natural drivers of kangaroo populations (Caughley *et al* 1985; Dawson 1995), and the necessity of taking lethal measures to alleviate the distress of free-ranging wildlife in response to natural environmental conditions is scientifically and ethically questionable (Bekoff 2010). Grigg (2002) also argues that kangaroos might impact on the welfare of other fauna dependent on the same habitats. Furthermore, relative to other domesticated animals that are part of Australia's enclosed and industrialised farming systems or live exports of farmed livestock for slaughter, it has been argued that kangaroos experience the welfare benefits of being free-ranging throughout their life, ideally with death being instantaneous from a shot to the brain (Grigg 2002).

Table 2 The estimated number of dependent young that are likely to die as collateral over ten years due to commercial killing of female kangaroos. The national commercial kill statistics from 2000–2009 (DSEPC 2010) are used to estimate the number of females and dependent young that are killed, based on the ten-year average reported for NSW for the same time-period (Mathews 2010).

Year	Red kangaroo (<i>Macropus rufus</i>)	Eastern grey (<i>M. giganteus</i>)	Western grey (<i>M. fuliginosus</i>)	Wallaroo (<i>M. robustus</i>)	Total killed	Females [†]	YAF [‡]	PY [§]
2000	1,173,242	1,106,208	227,552	238,439	2,745,441	775,945	193,986	543,161
2001	1,364,682	1,438,280	283,332	296,805	3,383,099	955,569	238,892	668,898
2002	1,500,588	1,810,426	330,372	257,140	3,898,526	1,118,130	279,532	782,691
2003	1,121,724	1,758,173	246,672	347,914	3,474,483	972,762	243,190	680,933
2004	988,203	1,466,325	233,496	304,047	2,992,071	836,812	209,202	585,768
2005	1,045,048	1,487,652	257,422	322,222	3,112,344	869,259	217,314	608,481
2006	1,184,554	1,510,250	288,914	305,658	3,289,376	925,681	231,420	647,977
2007	1,124,662	1,344,430	250,593	266,785	2,986,470	842,584	210,646	589,809
2008	804,278	911,815	201,199	275,915	2,193,207	602,779	150,694	421,945
2009	706,894	806,096	171,544	265,580	1,950,114	531,918	132,979	372,343
Decade total	11,013,875	13,639,655	2,491,096	2,880,505	30,025,131	8,431,438	2,107,855	5,902,007
Yearly average	1,101,388	1,363,966	249,110	288,051	3,002,513	843,144	210,786	590,201

The number of females killed is variable for reasons of demand and industry-imposed carcase size limits (see Department of Environment and Natural Resources 2010; Mathews 2010; Department of Environment and Resource Management 2011).

[†] The model assumes that 30% of kangaroos are females, except for wallaroos that are 10% (Mathews 2010).

[‡] Young-at-foot: 75% of females have pouch young.

[§] Pouch young: 25% of females have young-at-foot (Witte 2005).

Harm caused by the commercial killing of kangaroos: deliberate harm

Mortality of dependent young

The role of mother-young interactions in the survival of offspring in domestic and wild mammals is well acknowledged (Bradshaw & Bateson 2000; Nowak *et al* 2000). Although there is a common perception in rural communities that kangaroo young become independent of maternal care at permanent pouch exit (Croft 2004), physiological and behavioural studies indicate that this is far from the case. Rather, the lack of maternal care significantly diminishes the dependent young's likelihood of survival and may cause harm due to starvation and dehydration, as shown by studies on the role of milk in their diet. Although the relative proportion of energy supplied by lactation to pasture declines towards weaning, which is at one year for red kangaroos when young typically reach 10–12 kg (Sharman & Pilton 1964), 18 months for the eastern and western grey kangaroos (Poole 1975) and over 13 months for the common wallaroo (Dawson 1995), lactational demand on the mother peaks during the period from permanent pouch exit to weaning (Munn & Dawson 2003). Moreover, the reliance on milk needs to increase substantially for young to retain the same growth rate during drought when pasture quality decreases (Munn & Dawson 2003).

Age and gender of young-at-foot may play a role in their survival (Munn & Dawson 2010). High quality pasture may

promote survival of orphaned young (Stuart-Dick & Higginbottom 1989). However, known metabolic requirements (Dawson 1989; Munn & Dawson 2003), vulnerabilities to predation (Banks *et al* 2000), and low recruitment (ie survival of young to an age where they contribute to the kangaroo population as a whole) during drought (Newsome 1977; Shepherd 1987) or even during average rainfall years (Newsome 1965; Bilton & Croft 2004) suggests that the proportion of orphaned young-at-foot surviving would be negligible (Croft 2004). Together, these available data support the assumption that all dependent young (including young-at-foot) would likely perish after the loss of their mother, either through starvation, dehydration, or predation.

Due to a lack of empirical data, the mortality of dependent young is estimated on the basis of reproductive and behavioural ecology of kangaroos targeted by the commercial industry and historical industry records. On average, 75% of red kangaroo females will have pouch young at any one time (Bilton & Croft 2001). A ten-year average from NSW shows that approximately 30% of commercially killed grey and red kangaroos and 10% of wallaroos were female (Mathews 2010). Under typical conditions in north-western NSW, 50% of female red kangaroos and 60% of eastern and western grey kangaroo females are likely to have young-at-foot (Witte 2005). A conservative estimate for female kangaroos with young-at-foot in a commercially killed population, that precludes location-specific conditions, is 25% (Witte 2005).

Lactation dependence continues after permanent pouch exit as the young-at-foot typically suckles every 1.5–2 h throughout the day from that time until they are weaned (Russell 1989). On average, some three million kangaroos are commercially killed annually (Table 2). A projection based on the above considerations (as there is no formal assessment) and the national commercial kill statistics (Department of Sustainability, Environment, Population and Communities [DSEPC] 2010) for the period 2000–2009 estimates that approximately 840,000 females, 210,000 young-at-foot and 590,000 pouch young were killed annually (Table 2). Assuming an equal distribution of pouch-young ages being killed and that only about half are likely to be sentient, approximately 500,000 sentient dependent young are affected each year by the commercial killing of kangaroos.

Killing of pouch young

The Code specifies acceptable killing methods for dependent young of various ages (Table 1). Any targeted female kangaroos, including injured animals, must be “thoroughly examined for pouch young” (the Code, section 2.3). Pouch young are then to be euthanised by a forceful blow to the head or decapitation depending on the age of young (the Code, section 5.1).

Pouch young are thought to become sentient at roughly four months (Tyndale-Biscoe 2005; Diesch *et al* 2010), about half the pouch life of the commercially killed species (Dawson 1995). RSPCA Australia has questioned the appropriateness of the methods prescribed in the Code for killing of pouch young and the level of training and competency of shooters to perform these methods (RSPCA Australia 2002). The American Veterinary Medical Association (AVMA) recommends replacing manually applied blunt force trauma to the head with other methods, as much as possible (Anon 2013). Decapitation is considered acceptable, under the right conditions, although it notes that electrical activity continues in the brain for some time following decapitation (Anon 2013). While it has been recommended that animals need to be sedated or lightly anaesthetised prior to being decapitated (Reilly 1993), the significance of the ongoing brain activity for pain perception is still being discussed (Anon 2013).

The AVMA Panel on Euthanasia also states that:

[p]ersonnel using physical methods of euthanasia [such as a blow to the head or decapitation] must be well trained and monitored for each type of physical method performed to ensure euthanasia is conducted appropriately (Anon 2013).

However, the Code requires no formal training for the killing of dependent young and these practices are unmonitored in the field.

Inhumane killing of adult kangaroos

The Code states that shooters must aim for the brain (with the intent of achieving a humane kill). To support the Code, carcasses with body shots are not accepted by processors, creating a disincentive for shooters to bring in kangaroos that are not shot in the brain. Moreover, heads are removed in the field, leaving no trace of shots penetrating the neck

area (which is also partially removed) and the head. Nonetheless, in an examination of carcasses at meat processing plants, RSPCA Australia found that the overall proportion of head-shot kangaroos (determined by examination of carcasses that had heads removed, as described below) that were processed was 95.9% (RSPCA Australia 2002), meaning that the remaining 4% (or approximately 120,000 of the three million ten-year average) were shot in the neck or body and not as required by the Code.

Another study by Animal Liberation NSW, of carcasses in 25 chillers between 2005 and 2008, identified that up to 40% of kangaroos per chiller may have been neck shot (Ben-Ami 2009). The apparently large difference in the RSPCA Australia and Animal Liberation NSW estimates is due to differences in sampling methodology. Animal Liberation NSW sampling was based on whether the head was severed at or below the atlantal-occipital joint (Ben-Ami 2009), which is where the skull connects to the neck and therefore the most efficient severing technique is at this joint where the tissue is soft. Anywhere else in the neck area the knife will encounter stiff resistance from the neck bones. RSPCA sampling was based on bullet entry points in carcasses. The argument here is that a shooter would be unlikely to engage in this difficult cut unless it was necessary to conceal a neck wound.

Both the RSPCA Australia and Animal Liberation NSW estimates were compromised by the fact that the samples were taken of carcasses, without the heads, brought to chillers or meat processors, rather than in the field at the time of shooting. The true number of kangaroos killed without a shot to the brain or neck area and left in the field (because they will not be accepted by processors) is unknown. Therefore, the combination of the available information from the organisations and carcass-handling practices of shooters suggests that 4% or 120,000 adult kangaroos (of the average three million adult kangaroos that are killed annually; Table 2) is a conservative estimate.

Injury to adult kangaroos

The welfare of an injured wild animal will be poor if there is an injury and worse if there is also suffering. The animal welfare impacts of any control method depend on the capacity of the species to suffer, the duration and intensity of pain, distress or suffering, and the number of animals affected (Kirkwood *et al* 1994; Littin & Mellor 2005). An injury will cause pain, which impacts the welfare of the animal in the immediate term and may either heal or lead to death. A conservative estimate of the number of animals known to die following shooting injury to the neck is provided above, and a further unspecified number of animals are left in the field to either heal or die from an injury.

The injury may continue to cause direct pain (even if healed) or may lead to impaired motor functioning of limbs and particularly the jaw (because the head is targeted). Animals may also have multiple sensory functions that when impaired can cause suffering (Gregory 2004). For instance, damage to brain or other organs involved in vision, hearing, smell or other sensory processing could be expected to impair their ability to respond to their environment and to interact socially.

The pursuit of kangaroos prior to shooting, where this occurs, may also cause problems for kangaroos that are shot and survive or for others in the group. This has been shown for other animals subject to hunting (eg red deer [*Cervus elaphus*]; Bradshaw & Bateson 2000). In particular, kangaroos are highly susceptible to capture myopathy, a condition leading to pain and distress and which may lead to eventual death within days or weeks (Shepherd *et al* 1988). Survivors may suffer long-term impairment resulting in reduced fitness and reproductive success (Cole *et al* 1994). There is no work on the fate of injured kangaroos, or the wider impacts of the methods used for commercial killing. Therefore, a rigorous field-based study at the point of kill to assess shooting practices and the outcome for kangaroos is essential.

Harm caused by the commercial killing of kangaroos: indirect harm

Mortality of young-at-foot

Young-at-foot are often not killed because shooters either have difficulty catching them due their flight response (RSPCA Australia 2002; Croft 2004) and (if they do catch them) may feel that it is better to let the young-at-foot live (Croft 2004). RSPCA Australia (2002) recommends that the shooting of females should cease until the fate of young-at-foot is better understood (discussed below) and that the only way of avoiding cruelty to pouch young would be to not commercially kill females altogether. RSPCA Australia's recommendations have not been implemented to date, as stated by McLeod (2010):

There is currently no routine field auditing of compliance with the national Code of Practice for either commercial or non-commercial shooting. Field auditing of Code of Practice compliance would provide a more accurate picture of the extent of animal suffering.

The fate of orphaned young-at-foot remains an open question. The number of dependent young that escape euthanasia is unknown. The fate of these young also remains unknown. At present there is simply no reliable evidence of their fate or the extent to which their welfare is compromised. This issue cannot go on being ignored and remains, arguably, the highest priority.

Increased mortality during drought

The kangaroo industry has argued that the death of dependent young arising as a result of commercial killing of parents is considered to be a surrogate of natural mortality (Sheehan 2009). In other words, adults would die anyway from natural causes as would their young; the reduction of kangaroos therefore frees up resources and improves the survival and reproductive rates of remaining kangaroos (Pople *et al* 2010). However, commercial killing pressures may have an additive effect to natural mortality, particularly during drought. The greatest mortality in affected kangaroo populations, particularly in the early stages of drought, is likely to include large young (Newsome 1965; Poole 1973) and juveniles (Shepherd 1987). Further, Shepherd (1987) noted that western grey kangaroo mothers are likely to invest in their pouch young (as opposed to red mothers, which invest in themselves). The commercial killing is selective for the larger kangaroos of both sexes (Pople 1996,

2006) and long-term statistics for NSW show that 30% (other than wallaroos) are females (Department of Environment Water Heritage and Climate Change 2009). Thus, commercial killing can expose populations to greater mortality during climatic periods where the risk of population decline is already higher.

Social impacts and diminished evolutionary potential of individuals

Recent evidence suggests that the 'evolutionary potential' (development and transferral of genes) of individuals is likely to be affected by the fitness level and quality of mothers (East *et al* 2009). Female kangaroos are generally most reproductively successful between the ages of 6–15 years (Bilton & Croft 2004). The death of these larger females not only impacts nutritionally dependent offspring but may be detrimental to other group members due to a variety of social interactions and dependencies. Social learning from the mother is likely to be a key factor to survivorship into adulthood (Higginbottom & Croft 1999), particularly as diet preferences and the ability to discriminate amongst plants are likely to be learnt from the mother (Provenza 2003). Female kangaroos also invest in training offspring to discriminate among stimuli used to assess predation risk (for a review, see Higginbottom & Croft 1999). Females that associate frequently with the same individuals are able to graze longer because they can afford to be less vigilant (Carter *et al* 2009).

Social learning also occurs in male groups. Play-fights often occur between mixed-age groups to assist training and to assess potential competitors (Croft & Snaith 1991). Adult male kangaroos, particularly the more social eastern and western grey kangaroos, are thought to be important in maintaining group cohesion (Pople & Grigg 1999). The loss of larger and older adults from a population through a size-selective commercial killing (Pople 2004; Pople *et al* 2010) may have consequences for the fitness of the remaining individuals and destabilise social structures, (as already expressed by Grigg 1997; Croft 2004).

Animal welfare implications

The purpose of the *Code of Practice for the Humane Shooting of Kangaroos and Wallabies* is to:

ensure all persons intending to shoot free-living kangaroos or wallabies... undertake the shooting so that the animal is killed in a way that minimises pain and suffering (Section 1.1).

It does not override state or territory animal welfare legislation but seeks to provide technical specifications and procedures, including procedures for the euthanising of injured kangaroos, pouch young and young-at-foot (Department of Sustainability, Environment, Water, Population and Communities [DSEWPoC] 2012). As such, it is the key regulatory instrument for the killing of kangaroos that relates to animal welfare (Boom & Ben-Ami 2011).

Our analysis suggests that some provisions in the Code relating to best practice by shooters are not met. First, it is unlikely that young-at-foot are killed when their mothers are shot (see above) as required by the Code (Table 1).

Second, there is a strong concern about the fate of mis-shot adults. As noted above, existing evidence from RSPCA Australia and Animal Liberation NSW suggests that many kangaroos are not shot in the brain per the desired welfare standard in the Code (Table 1), and it is impossible to know how many mis-shot kangaroos are left in the field.

The mandated methods for pouch young euthanasia have also been questioned, as discussed above, and there is no requirement for training in the Code — for either the killing of adults, or euthanasia of pouch young.

Possible alternatives

Alternative killing mechanisms are not viable for the kangaroo industry because kangaroos cannot be farmed or held in fenced enclosures. The cost of fencing for kangaroos (compared to livestock) are prohibitive and they experience capture myopathy when stressed (Shepherd 1983). Rather, we suggest several changes to at least bring the industry's welfare practices to the standard already mandated by the Code: i) amending the Code to clearly provide that kangaroos must be shot in the brain (rather than requiring that shots be aimed at the brain); ii) that shooters retain the heads on carcasses so adherence to the Code can be monitored at processing; iii) that only kangaroos shot in the brain will be accepted for processing; iv) mandating a male-only kill would ensure that the welfare of young is not compromised; and v) adopting adaptive management concepts, such as using new knowledge to constantly update guidance and practices (Warburton & Norton 2009). However, even if these changes were adopted, a significant welfare concern would remain unresolved, as there will always remain a proportion of adult animals that are not shot correctly, left in the field, and suffer.

The ethics of the kangaroo industry

Benefits of the kangaroo industry include income to participants in the industry and some cost reduction to graziers (much less than previously thought). Although there is thought to be a potential for a positive impact on the environment, supporting evidence is lacking. The commercial kill may also ameliorate the deaths (ease the suffering) of kangaroos during drought. The costs include deliberate and indirect harm to dependent young, and a number of unintended harms to adult kangaroos. These include increased mortality during drought, inhumane killing of a portion of adult kangaroos, and a disruption of social stability and the evolutionary potential of individuals.

The benefits derived from the kangaroo industry are lower than previously thought, and the welfare costs are higher than expected. Moreover, if the Code establishes the welfare standard that the industry itself aspires to, then the substantial gap between the intended and the actual welfare outcomes for kangaroos in the commercial kill requires better enforcement and improved policy (suggested above) to mitigate harm.

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