

A review of roadkill rescue: who cares for the mental, physical and financial welfare of Australian wildlife carers?

Bruce Englefield^{A,B}, Melissa Starling^A and Paul McGreevy^A

^AFaculty of Veterinary Science, University of Sydney, NSW 2006, Australia.

^BCorresponding author. Email: beng3578@uni.sydney.edu.au

Abstract. The non-human animal deaths and injuries that result from collisions with motor vehicles are known colloquially as roadkill, and often lead to individuals from various taxa being orphaned. The complexities of multiple spatial and temporal variables in the available data on Australian roadkill and the scale of orphaning and injury make statistical analysis difficult. However, data that offer proxy measures of the roadkill problem suggest a conservative estimate of 4 million Australian mammalian roadkill per year. Also, Australian native mammals are mainly marsupial, so female casualties can have surviving young in their pouches, producing an estimated 560 000 orphans per year. A conservative estimate is that up to 50 000 of these are rescued, rehabilitated and released by volunteer wildlife carers. These roadkill-associated orphans are in addition to those produced by other anthropogenic and natural events and the injured adult animals in the care of volunteers. In accepting total responsibility for rescued animals, wildlife carers face many demands. Their knowledge base can require days of initial instruction with the need for continual updates, and their physical abilities and personal health can be tested by sleepless nights, demanding manual tasks and zoonoses. This review article explores the impact of this commitment and conservatively estimates carers' financial input to raise one joey at approximately \$2000 a year, and their time input at 1000 h, equating to \$31 000 per year, applying a dollar value of \$31 per hour. It categorises relevant types of grief associated with hand-rearing orphans and rehabilitating injured animals, and suggests that wildlife carers most likely experience many types of grief but are also susceptible to burn-out through compassion fatigue. A perceived lack of understanding, empathy and appreciation for their work by government can add to the stressors they face. Volunteering is declining in Australia at 1% per year, social capital is eroding and the human population is aging, while the number of injured and orphaned animals is increasing. Wildlife carers are a strategic national asset, and they need to be acknowledged and supported if their health and the public service they provide is not to be compromised.

Additional keywords: carer burnout, carer stressors, orphaned wildlife, roadkill numbers, wildlife carer.

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Introduction

The advent of motorised transport has not only altered environments but also presents a unique primary threat to wildlife. Human dependence on vehicular transport has had considerable influence on faunal populations across the world (Trombulak and Frissell 2000; Davenport and Davenport 2006; Coffin 2007). For example, in Europe, roadkill is the main cause of the decline of the critically endangered European mink (*Mustela lutreola*) (Palazón *et al.* 2012). Cars are among the biggest threats to the highly endangered Florida panther (*Puma concolor coryi*), with 10–15 panthers killed by vehicles each year (Fergus 1991; Waymer 2014) and, from the International Union for Conservation of Nature Red List, in less than a year, one tiger (*Panthera tigris*) and two leopards (*Panthera pardus*) were killed by speeding vehicles on the state highway at Sariska Tiger Reserve, Alwar, Rajasthan India (Baskaran and Boominathan 2010). In Australia, roadkill can be a tipping point and represent a threshold beyond which there are serious threats to species as

the result of disease, habitat destruction or anthropogenic events. Examples are the endangered Tasmanian devil (*Sarcophilus harrisii*) (Jones 2000; Hobday and Minstrell 2008), endangered koalas (*Phascolarctos cinereus*) (Lunney 2013; McAlpine *et al.* 2015) and threatened wombats (*Vombatus ursinus*) (Roger *et al.* 2007).

Dead and injured animals are constantly found along Australian roads. The density of roadkill can reach as high as one dead animal every 3 km per day. As disturbing as this number is, the survey from which this statistic is drawn (Hobday and Minstrell 2008) included only those seen dead on the road or verge from a vehicle and not in the adjacent vegetation. There may be many physical, environmental and cognitive factors influencing the behaviour of both animals and human drivers involved in such incidents, and these contribute to the fundamental issue of drivers and wildlife being unable to adequately predict an imminent collision and act to avoid it. These lethal interactions involve most taxa and

produce what has become known as roadkill. Non-lethal interactions often injure animals and may lead to a slow death unless victims can be rescued or euthanased. Managing the rescue and rehabilitation of animals injured by vehicles, as well as by other anthropogenic events, is a huge undertaking. In the United States, members of the National Wildlife Rehabilitators Association (NWRA) treat hundreds of thousands of wildlife animals annually and more than 75% of the animals cared for have been directly affected in some manner by human activities (NWRA 2017). In the United Kingdom, data from 2013 indicate that the Royal Society for the Prevention of Cruelty to Animals (RSPCA) UK, treated more than 15 000 sick, injured or orphaned wildlife animals (RSPCA 2017), while in Australia, 25 568 native wildlife animals were presented to the RSPCA Australia from July 2015 to June 2016 (RSPCA Australia 2016).

Generally, when pregnant or nursing females are killed by road traffic or by other anthropogenic means (including cat and dog attack, gunshot, habitat challenges and deliberate acts of cruelty), their offspring die with them, either by fatal injury at the time, or subsequent starvation in the nearby environment or maternal den. However, in Australia and parts of South America, deaths of lactating females present a unique problem. Australia has 357 indigenous mammal species, of which 159 are marsupials (Van Dyck and Strahan 2008; Chapman 2009). When marsupial females are killed, the young in the pouch often survive the mother and may be sufficiently developed to be hand-reared. There may also be joeys that have left the pouch but are still dependent on the mother for feeding and so stay near her. A decision must be made as to what to do about these orphans, if they are found while still alive. The options available are non-intervention, euthanasia or rescue and rehabilitation.

Some ecological theorists interpret animal rights theory as a 'hands-off' approach and decry human interference in the processes of the natural world (Bekoff and Hettinger 1994; Hettinger 1994; Francione 2008; Rolston 2012). This approach has been described as the 'laissez-faire intuition' (Palmer 2010), but its critics argue that if it is accepted that wild animals have an inalienable right to life, then non-intervention and letting nature take its course is neither morally nor ethically acceptable (Callicott 1980; Cohen and Regan 2001). This could be seen as particularly valid when humans have caused the harm by roadkill, agricultural practices (culling) or by keeping uncontrolled domestic pets (predation). Those involved in wildlife rehabilitation argue that there is a moral obligation to give anthropogenic casualties a second chance wherever possible (McKeever 1979; Thomas 1993; Hutto 1995). Rescuing joeys from the pouch of a dead or injured mother could be seen as positive intervention that has the potential to remediate a human-caused harm.

Euthanasia of animals, perhaps especially where it concerns native species, is a sensitive and emotive topic and can raise vigorous public debate. The recent global outrage on social media when Harambe, a male western lowland gorilla (*Gorilla gorilla gorilla*) at Cincinnati Zoo, was shot and killed because a child's life seemed in danger (McCabe 2016) demonstrates the sensitivity of using euthanasia, even as a considered reaction to a human life-threatening event. RSPCA Australia

policy on orphaned wildlife contends that only where rehabilitation and release is unlikely to be successful, should the animal be humanely euthanased (RSPCA Australia 2008). It is also questionable whether veterinarians, registered with the Australian Veterinary Association (AVA), could undertake euthanasia of a viable, healthy joey or injured animal that could be rehabilitated, without breaching the AVA's code of professional conduct (Australian Veterinary Association 2018: p.1, line 1) which states 'The community and your clients are entitled to expect that you will always consider the health, welfare and respectful treatment of the animal'.

If non-intervention and euthanasia are discounted, then rescue-and-rehabilitation is the remaining option. The current Australian environmental, ethical and legal frameworks for these orphaned animals involve their being hand-reared by volunteer wildlife carers, treated as wild animals and eventually returned to the wild, or held in captivity in perpetuity. This can be seen as a public service, as the financial cost for these frameworks is borne largely by the wildlife carers themselves.

There are no national data on roadkill numbers, orphaned or injured animals, the number of registered and unregistered wildlife carers, the period wildlife carers spend as carers, the rate of recruitment and resignations of wildlife carers; nor is there any monitoring of the survival rate and welfare of animals that are released. The national data collected by vehicle companies or RAC are animal-related crash data rather than road-kill statistics.

A few state-based studies hint at the scale of the problem presented by anthropogenic marsupial deaths and injuries (Guy and Banks 2010). Unfortunately, they tend to target differing species, animal densities, types of road, States and Territories, years, traffic volumes, traffic speeds and seasonal patterns. With inconsistent treatment of so many variables in different datasets, and roadkill fatalities being points in both time and space, the complex process of statistical analysis is very challenging, if not impossible.

For the current review, it was decided that conservative estimates would be sufficient to demonstrate the size of the roadkill problem, and so evaluate the merits of data that may act as possible proxy measures of the scale of roadkill-related injuries and the numbers of consequent deaths and orphans. There is little published information on the public service provided by wildlife carers to Australia in raising and rehabilitating orphan animals and rehabilitating injured animals. This leaves a large knowledge gap when we try to understand the size, complexity and sustainability of the present system of managing wildlife casualties.

This review uses the data available in the primary literature on the frequency of roadkill in certain Australian states and provides an estimate of the numbers of marsupial roadkill and how many orphans may require care as a result of roadkill. These figures, combined with an estimate of the financial costs of raising orphaned pouch-young and the number of active carers across the country, provide for the first time an approximation of the financial burden of raising orphaned pouch-young Australia-wide. The review goes on to describe the other facets of the possible impacts on wildlife carers, including the potential physical demands and psychological costs associated with the task.

Methods

A systematic search was performed of the Australian research literature from 1973 until 2017. Data were obtained using the search terms 'Australian wildlife roadkill', 'road crashes involving wildlife' and 'animal road mortality' in the University of Sydney library cross-search engine and Google Scholar. From this sweep, 14 studies of Australian mammalian roadkill were identified and extracted (Table 1). Particular emphasis was placed on findings from studies that included all or most mammal species extant in the study area, covered at least 50 km of roadway, and with data collected over at least a year. A calculation was made for the roadkill per km per day using data on the reported number of animals killed in these studies, the period over which the study took place and length of road under observation. The lowest rates obtained for roadkill per km were then extrapolated upwards, using the total road length in Australia, to arrive at a conservative estimate of the number of Australian mammalian roadkill per year. This figure needed further adjustment because the roadkill data in previous studies were recorded from vehicles travelling along highways. Surveys conducted on foot through the road verges and adjacent bush areas revealed that a further 30% of the number of roadkill observed from vehicles remain unrecorded by these studies (Hobday and Minstrell 2008; Knowler 2015; N. Mooney, wildlife biologist, pers. comm. 2017).

No national data are collected on the number of animals orphaned as a result of anthropogenic events. Several sources were consulted to obtain an estimated number, including the RSPCA Australia, not-for-profit wildlife carer organisations (Wildlife Rescue Service New South Wales, Wildlife Victoria, Native Animal Network of South Australia, Wildlife Preservation Society Queensland, Western Australian Wildlife Rehabilitation Council Inc., Tasmanian Wildlife Rehabilitation Council, Australian Capital Territory Wildlife, Wildcare Inc. Northern Territory), individual wildlife carers, manufacturers of replacement milk powder for rearing orphaned joeys (Wombaroo, Biolac, Passwell) and a roadkill survey (Department of State Growth 2017). Information was received on the number of joeys rescued, the number of joeys released, the number of active wildlife carers in Australia (Table 2), the quantity of milk powder produced (which was received as business-in-confidence information) (Table 3), the quantity required to raise joeys of various species (Table 4) and the ratio of rescued joeys to number of adult roadkill deaths (Department of State Growth 2017). Separate estimates were made using each dataset. A final estimate was obtained by taking an average of the results.

Representative organisations from each State were each contacted to obtain approximate data on the number of registered wildlife carers in Australia (Table 2). Specifically, the president or secretary of each registered rehabilitation centre or rehabilitation network organisation was asked for membership numbers. For those states (Western Australia and South Australia) with no centralised carer database, carers were contacted on a group or individual basis.

Details of the qualifications required of wildlife carers were sourced from individual carers, carer organisations, food manufacturers, equipment suppliers, websites and personal experience from being a wildlife carer over a 10-year period. These data were collated to estimate the workload and financial costs involved in being a wildlife carer (Table 5).

The risks for wildlife carers suffering psychological stress while caring for injured, traumatised or suffering animals were investigated by conducting a search of peer-reviewed international literature (from 1989 to 2016), using the search terms 'grief', 'grief and loss', 'grief therapy', 'grief counselling' and 'definition of grief' in the University of Sydney library's cross-search engine and Google Scholar. Papers that discussed at least eight of the most commonly listed types of event that could cause human grief were examined. The types of grief reported in these papers were then tabulated against definitions for 18 recognised types of grief (Table 6). Finally, using these definitions, the different types of grief that could be experienced by a wildlife carer were predicted and comparisons made with the other types of grieving events and their resultant types of grief, to demonstrate how wildlife carers could experience 15 of the 18 defined types of grief. Compassion fatigue or secondary post-traumatic stress disorder may well affect wildlife carers, so a further search was conducted using the same search engines and the search terms 'compassion fatigue', 'traumatic events' and 'caregiver burnout'. These papers were examined to explore how compassion fatigue may affect wildlife carers.

Results

Calculating conservative estimates of marsupial roadkill

Using data from studies on roadkill conducted on a limited scale within individual Australian states (Table 1), specifically the column for average roadkill per km per day, the estimates for marsupial roadkill range from 0.0041 per km per day (footnote A), see Department of State Growth 2017; Table 1, on a remote Tasmanian road with little traffic (Department of State Growth 2017) to 0.074 per km per day (footnote C), see Hobday and Minstrell 2008; Table 1, on Tasmanian urban and rural highways with moderate-to-heavy traffic (Hobday and Minstrell 2008). In 2012, the total network length of both sealed (bitumen) and unsealed (gravel) roads in Australia was 900 082 km (D), (Bureau of Infrastructure, Transport and Regional Economics 2014). Local rural roads make up 60% of Australian road infrastructure, with 14% being local urban roads, 23% rural highways and arterial roads, and 3% urban highways and arterial roads. Therefore, with 60% of Australian roadways similar to (footnote A), a remote Tasmanian road with little traffic and (footnote B), a NSW rural road, then a figure of 0.011 per km per day (E), (midway between (footnote A) 0.0041 and (footnote B), 0.018) is favoured to produce a conservative estimate of marsupial roadkill. Using 0.011 per km per day, the estimated yearly figure for total Australian marsupial roadkill is 3 600 000 (i.e. $E \times D \times 365$). However, these data are for roadkill reported as present on the road or verges, counted from a vehicle, and do not include animals that have managed to move out of sight before dying of their injuries. To obtain these data, several roads were surveyed in Tasmania between 2002 and 2008 using a vehicular drive-through; they were then resurveyed until no more previously unseen roadkill were recorded. Then the verges were searched on foot. (N. Mooney, wildlife biologist, pers. comm. 2017). The number of new roadkill was estimated at a further 30% of the number of roadkill recorded from vehicle observation. Being conservative again by using only 15% (half the 30% factor) to further

Table 1. Australian marsupial wildlife roadkill showing variables involved in producing an estimate of average roadkill per km per day

Note that Osawa (1989), Driessen et al. (1996), Mallieck et al. (1998), and Ramp and Ben-Ami (2006) reported on only one species; Coulson (1982) reported on only two species. For some papers, the set of species indicated for each study is a minimum set rather than the full set. MBP, mountain brushtail possum (*Trichosurus caninus*); B, bettong (*Bettongia*); NBB, northern brown bandicoot (*Isodon macrourus*); BFF, black flying fox (*Pteropus alecto*); P, pademelon (*Thylogale*); BTP, brushtail possum (*Trichosurus vulpecula*); RK, red kangaroo (*Macropus rufus*); BW, Bennett's wallaby (*Macropus rufogriseus rufogriseus*); RNW, red-necked wallaby (*Macropus rufogriseus*); CW, common wallaroo (*Macropus robustus*); RTP, ring-tail possum (*Pseudocheirus perigrinus*); EBB, eastern barred bandicoot (*Perameles gunnii*); SBB, southern brown bandicoot (*Isodon obesulus*); EGK, eastern grey kangaroo (*Macropus giganteus*); STQ, spotted tail quoll (*Dasyurus maculatus*); EQ, eastern quoll (*Dasyurus viverrinus*); SW, swamp wallaby (*Wallabia bicolor*); GHFF, grey-headed flying fox (*Pteropus poliocephalus*); TDV, Tasmanian devil (*Sarcophilus harrisii*); K, koala (*Phascolarctos cinereus*); W, common wombat (*Vombatus ursinus*); LNB, long-nosed bandicoot (*Perameles nasuta*); WGK, western grey kangaroo (*Macropus fuliginosus*)

Author/originator	Location/date	Sampling rate/Number of days	Length of road km	Traffic density vehicles per day	Speed limit km h ⁻¹	Environment/type of road	Species	Roadkill number	Average roadkill per km per day
Vesjens 1973	ACT NSW 1970–1972	Monthly 24	301.0	n/a	n/a	Rural/urban Bitumen/gravel	BTP, RTP, EGK, RK	72	0.010
Coulson 1982	Vic 1975–1980	Periodic 124	20.0	~1000	100	Rural bitumen	EGK, SW	32	0.013
Osawa 1989	Qld 1981–1982	Monthly 365	23.0	n/a	100	Rural–urban transition bitumen	SW	127	0.015
Driessen et al. 1996	Tas 1992–1996	Quarterly 1 149	1 699.0	n/a	50–100	Rural bitumen	EBB	2 350	0.0012
Mallieck et al. 1998	Tas 1992–1996	Quarterly 180	96.0	n/a	80	Rural bitumen	EBB	256	0.015
Klöcker et al. 2006	NSW 2002	Every other day 168	21.2	~50	100	Rural bitumen	WGK, EGK, RK, CW	125	0.035
Taylor and Goldingay 2004	NSW 2000–2001	Weekly 120	100.3	5000–20000	60–100	Rural bitumen	NBB, LNB, BTP, K, RTP, SW, BFF, GHFF	211	0.018 ^B
Ramp et al. 2005	NSW 1998–2003	Twice daily 2 190	40.0	~500	100	Rural bitumen	EGK, SW, RNW, W	2 916	0.033
Giffney et al. 2009; Ramp and Ben-Ami 2006	NSW 2004–2006 NSW 2003	Bi-weekly 104 Daily 143	80.0 22.0	n/a ~3000	50–100 60–80	Urban bitumen Rural–urban transition bitumen	BTP, RTP SW	591 14	0.07 0.0045
Bond and Jones 2008	Qld 2004	Twice weekly 122	1.3	n/a	70	Rural bitumen	RNW, SW, RTP, NBB	6	0.038
Hammond 2008	Tas 2007–2008	Every 4 days 91	21.7	n/a	100	Rural bitumen	BW, B, BTP, P, SBB, STQ	251	0.13
Hobday and Minstrell 2008	Tas 2001–2004	Periodic 616	99.2	n/a	50–110	Rural and urban bitumen and gravel	BTP, P, BW, TDV, W, EBB, RTP, SBB, STQ, B, EQ, LNB	4 533	0.074 ^C
Department of State Growth 2017	Tas 2013–2016	Weekly 143	97.2	~70	60–100	Rural bitumen and gravel	P, TDV, BW, W, BTP	57	0.0041 ^A

^A57 (roadkill) divided by 97.2 (km of road) divided by 144 (days reported) = 0.0041 roadkill per km per day.

^B211 (roadkill) divided by 100.3 (km of road) divided by 120 (days reported) = 0.018 roadkill per km per day.

^C4533 (roadkill) divided by 99.2 (km of road) divided by 616 (days reported) = 0.074 roadkill per km per day.

extrapolate the previous figure of 3 600 000 marsupial roadkill, the figure 4 140 000 is obtained. It is therefore concluded that a conservative estimate of marsupial roadkill in Australia exceeds 4 million per year.

Table 2. Wildlife carer organisations by State or Territory

State or Territory	Number of organisations	Number of carers
New South Wales	34	5000
Victoria	50	3300
Queensland	59	2200
Western Australia	25	3150
South Australia	20	1340
Tasmania	13	300
Australian Capital Territory	2	60
Northern Territory	4	210
Total		15 560

Calculating an estimate of rescued joey orphans

The percentage of female marsupial roadkill that carry pouch-young is largely unrecorded. A roadkill monitoring report for the Tarkine Drive upgrade in Tasmania (Department of State Growth 2017) indicates the presence of viable joeys in ~14% of roadkill marsupials endemic to this area: the Tasmanian devil

Table 3. Total milk replacer manufactured by Wombaroo, Biolac and Passwell

Species	Production per year (kg)	Allocation (kg)
Kangaroo/wallaby	107 000	Kangaroos 10 000, wallabies 97 000
Wombat	8000	8000
Possum	7000	Brush-tail 6930, ring-tail 70
Koala	5000	5000

Table 4. Estimates of milk usage by each of the commonly hand-reared marsupial species, cost of milk and animals reared

Species	Dry weight of replacement fed per orphan (kg)	Cost (AUD)	Approximate minimum number of animals that could be reared per year
Brush-tail possum (<i>Trichosurus vulpecula</i>)	0.6	40	11 500
Common wombat (<i>Vombatus ursinus</i>)	10.0	260	800
Eastern grey kangaroo <i>Macropus giganteus</i>	15.0	520	660
Koala (<i>Phascolarctos cinereus</i>)	5.0	130	1000
Red-necked wallaby (<i>Macropus rufogriseus</i>)	7.5	260	12 900
Ring-tail possum (<i>Pseudocheirus perigrinus</i>)	0.3	20	230

Table 5. Cost of rearing a red kangaroo joey to point of release in Australian dollars

Description	Quantity	Cost per item (AUD)	Total (AUD)
<i>Infrastructure and consumables</i>			
Cage/box	1	50.00	50
Hanging pouch frame	1	30.00	30
Pouches	5	15.00	75
Heat pad	2	69.00	138
Feed bottles	5	6.00	30
Teats	40	1.30	52
Mixing bowl, jug and whisk	1	25.00	25
Playpen	1	119.00	119
Cloth towels	4	2.00	8
Paper towel rolls	12	2.08	25
Food bowl and water bowls	2	10.00	20
Weighing scales	1	140.00	140
<i>Food</i>			
Milk substitute	1		520
Macropod pellets	1		96
<i>Proprietary/prophylactic medications</i>			
Skin lotions toltrazuril, peptosyl, non antibiotic scour treatment, avermectin			50
<i>Education</i>			
Stationery and books			200
Training courses, registration, insurance			250
Vehicle costs and vet checks			172
Total			\$2000

Table 6. Types of events that cause grief and the types of grief associated with them

Types of grief	Death of a spouse (Waskowic and Chartier 2003)	Death of a parent (Umberson 2003)	Death of a child (Keese et al. 2008; Lin and Lasker 1996)	Marriage break up (Bacon 2001)	Parents with disappeared children (Hollander 2016)	Palliative care to the end of life (Stada 2013; Matzo and Sherman 2014)	Children leaving home (Raup and Myers 1989)	Death of a pet (Adams 1996; Rochester 2011)	Rearing an animal for release
Abbreviated				X				X	X
Absent	X		X	X	X	X		X	X
Ambiguous					X				X
Anticipatory	X	X					X	X	X
Chronic		X	X		X	X			X
Collective	X								
Cumulative			X					X	X
Delayed		X				X		X	X
Disenfranchised	X			X	X		X	X	X
Distorted			X					X	X
Exaggerated			X					X	
Inhibited		X				X		X	X
Masked		X							X
Prolonged		X	X		X			X	X
Secondary				X					
Traumatic	X				X	X		X	X
Unanticipated	X	X	X			X		X	X
Unresolved					X		X		X

(*Sarcophilus harrisi*); Tasmanian pademelon (*Thylogale billardieri*); Bennetts wallaby (*Macropus rufogriseus*); common wombat (*Vombatus ursinus*); and the brushtail possum (*Trichosurus vulpecula*). However, no female marsupials carrying multiple joeys were recorded in the roadkill, despite this being expected in several species, including Tasmanian devils and quolls (*Dasyurus*). This outcome seems unlikely and may reflect insufficient pouch-checking by those monitoring the roadkill. If this were the case, such an omission would have reduced the reported percentage considerably. Proposing a national figure from just one small dataset is not without risk, but applying the Tarkine Drive percentage (14%) to the conservative 4-million estimate of roadkill (see above), gives an estimate of 560 000 pouch-young that may survive their mothers' deaths. The rural nature of most Australian roads (with 60% being remote and unpaved), the 30% of roadkill unseen from the road (see above) and the inherent lack of pouch-checking leads us to surmise that 85–95% of these young die before rescue. Thus, we estimate that between 28 000 and 84 000 roadkill-related orphans might be rescued.

Milk replacer and number of orphans it would feed

After being approached by phone, the three major Australian manufacturers of milk replacer supplied data by email or verbally on the full understanding that it was 'commercial-in-confidence' information. Collated data show that ~127 tonnes of milk-replacement products are produced to hand-feed and rear joeys to the stage of weaning each year. Table 3 presents the maximum amount of milk replacer needed to rear a joey of each of the commonly hand-reared marsupial species from its minimum viable weight at rescue to a weight ready for weaning. Wallabies and kangaroos, and brushtail and ringtail possums are fed the same formula milk powder. The ratio of wallaby

roadkill to kangaroo roadkill is ~10:1 and that of brushtail to ringtail possums 100:1 (Lee *et al.* 2004; Leeuwenburg *et al.* 2004; Taylor and Goldingay 2004; Ramp *et al.* 2005; Hobday and Minstrell 2008). Applying these ratios, and assuming that joeys are rescued in the same ratio, ~97 000 kg of milk replacer could be fed to wallaby joeys and 10 000 kg to kangaroo joeys per year (10:1). Similarly, 6930 kg of milk replacer could be fed to brushtail possums and 70 kg to ringtail possums per year (100:1). When rescued, many joeys weighing more than the minimum viable weight have already received milk from their mothers, so require less time, and therefore less milk than estimated here, to rear them to weaning. Approximately 5–10% of joeys die early during the rearing process (milk manufacturer 2017, pers. comm; Tribe and Brown 2000; Department of Primary Industries Water and the Environment Tasmania 2017 pers. comm.), meaning that, relative to completed rearing, smaller volumes of milk may be consumed as a result of these deaths and can therefore be discounted. The cost of the powder and protracted 'best before' date of 18 months on milk replacer mean that wastage or stockpiling by carers is <1% and can also be discounted.

Using these data, and assuming minimal wastage, the milk powder produced is estimated to be sufficient to hand-rear a minimum of 40 000 joeys a year. The number of joeys that are reared using products other than milk powder substitute, e.g. goats' milk is discounted.

Calculating the number of wildlife carers

There are more than 200 registered wildlife-carer organisations in Australia with ~15 560 registered members (Table 2). However, a wildlife organisation may have many branches, e.g. NSW WIRES (NSW Wildlife Information, Rescue and Education Service), which is the nation's largest carer

organisation, has 31 branches, and South Australia NAN (Native Animal Network Inc.) has 14 branches. Nevertheless, each multi-branch organisation was counted in our calculation only once per State or Territory. As mentioned previously, there are a minimum of 5000 unregistered carers so, in total, the minimum number of wildlife carers is 20 560.

WIRES has ~2500 registered members, of whom ~1500–1600 (60–64%) are actively caring for animals. In 2016, these members released to the wild 14 004 bandicoots, possums, gliders, macropods, antechinus, wombats, quolls, koalas and pademelons. Unfortunately, no data are available on how many of these were hand-reared orphans and how many were injured and rehabilitated rescued animals. It has been suggested that, on average, carers hand-rear 3–4 animals per year (WIRES 2017, pers. comm.).

If we accept the above information for roadkill orphans and the milk powder manufactured to rear them as being enough to rear a minimum of 40 000 joeys per year, the number of wildlife carers as 20 560 (of which 60–65% or ~12 300–13 200 are active) and animals reared and released as 3–4 per carer per year, an approximate conservative estimate for the total number of joeys rescued, rehabilitated and released would be 50 000 a year.

Impact on carers

As well as the skills, commitment and time required of wildlife carers, there are two major costs that they experience: financial and emotional.

Financial costs

As a condition imposed under all State and Territory regulations, every wildlife carer must agree to be responsible for the total financial costs of rearing orphan joeys and rehabilitating injured adults. A specific case of rearing a red kangaroo, *Macropus rufus* (the largest terrestrial mammal native to Australia), is provided here (Table 5) to illustrate maximal possible costs involved in raising just one orphan joey. It is worth noting that only food costs are reduced significantly when smaller species are reared. Many of the other costs, including infrastructure, medical expenses, education, training courses and transport (Table 5) remain almost constant.

Although many veterinarians work pro bono or charge wildlife carers very little, other costs do often include veterinary treatment, the need to communicate with others, transport for an animal, travel to meetings and training courses and general shopping, and involve information technology and transport costs. Attending a basic course, such as the Rescue and Immediate Care Course (RICC) run by WIRES NSW, costs \$175 (which also covers the first-year membership fee). This expense is non-negotiable because the RICC is a prerequisite to becoming a registered carer. Public and personal liability insurance is another essential cost, although this may be covered by membership of a wildlife carer organisation. Events such as a carer being injured when rescuing an animal, or having a released animal injure a member of the public or cause a vehicle accident, all call for insurance cover. The carer may not be responsible, but the legal costs can be considerable in defending any action brought against a wildlife carer.

Housing and pre-release pens cost up to \$4000–\$5000 but can be used for a series of joeys. Similarly, stationery and books, training courses, registration and insurance can be assigned to the rearing of multiple joeys.

Psychological effects

A search of the literature revealed eight of the most general type of experiences that can cause grief, and these are correlated with 18 types of grief that can be experienced in human lifestyle and personal relationships (Table 6). The last column in Table 6 illustrates the number of different types of grief that could be experienced by wildlife carers while rearing an orphaned or rescued animal. For example, having the animal die could be compared with the death of a pet or child; releasing the animal to the wild and not knowing if it survives could be compared with children leaving home or having pets or children go missing.

Discussion

Australian native animals are injured and orphaned at rates that require more than 200 registered carer networks and over 15 560 registered volunteer wildlife carers to meet the challenge of caring for injured animals (mammals, birds, fish and reptiles) and hand-rearing rescued orphans. There are also many other unregistered people involved; Tasmanian authorities do not require wildlife carers to be registered if looking after certain species, such as possums and wallabies, and South Australia does not require registration to obtain a permit to keep injured or orphaned native wildlife. Western Australia has no registration system, although people can join registered organisations. So no data exist on the number of individual wildlife carers acting outside these carer-network registers. This gives some indication of the size of the problem presented by orphaned and injured animals in Australia. Volunteers dedicate not only their time, physical effort and emotional input to this endeavour, but also contribute a significant amount of their own money. To put these financial and time contributions into a national perspective, at a level of one carer raising just one joey a year with an input of 1000 h and \$2000 as discussed previously, the contributions from the national volunteer force amount to 20 000 000 h and \$40 000 000. In NSW last year the average number of animals reared and released by each wildlife carer was 9.3. Approximately 14 000 marsupial joeys were rehabilitated and released by 1500 active carers in NSW in 2016, which equates to an average of 9.3 animals per carer per year, i.e. 14 000 divided by 1500. (WIRES 2017, pers. comm.).

Using this approximation the national figures would be 186 000 000 h and \$370 000 000 of financial outlay. Applying a dollar value of \$31 h⁻¹ (Sunners 2015) to the 186 000 000 h put in by carers brings the value of this work to \$5 766 000 000. When this is added to the financial outlay of \$370 000 000, the total amounts to ~6 billion dollars of volunteer in-kind and financial input.

When carers undertake to rear and rehabilitate native orphan and injured animals, they assume significant responsibilities. Although they are volunteers, they need a broad knowledge base in animal care, behaviour, legislation and policy to successfully rehabilitate a wild animal. Professional wildlife

parks, e.g. Healesville Sanctuary, Bonorong Wildlife Sanctuary and Currumbin Wildlife Sanctuary rear very few orphaned animals themselves. They take them in for veterinary assessment and then place them with wildlife carers. (Healesville Sanctuary, 2017 pers. comm; Bonorong Wildlife Sanctuary 2017; Currumbin Wildlife Sanctuary 2017). Wildlife carers must undertake training before obtaining any animal and must subsequently ensure that their skill-base is kept updated on rehabilitation techniques, legislation and policies. (Tribe and Brown 2000; Gage 2002; Stocker 2005; Tribe *et al.* 2005). The financial demands of caring for wildlife usually reflect the need to supply all food, medicines, laundered pouches, sterilised bottles and teats, as well as safe and secure housing. The physical effort involved in rearing an orphaned joey or rehabilitating an injured individual, particularly those of larger species, may have a deleterious effect on the health of wildlife carers, especially those who are experiencing sleep deprivation from adhering to a 1- to 3-hourly feeding schedule day and night (Gay *et al.* 2004; Klumpers *et al.* 2015). There are over 60 diseases in Australia that can be transmitted from animals to humans, and carers are exposed to faeces, respiratory secretions and blood on a daily basis (Fowler 2007). Carers need to be constantly aware of the occupational risks they encounter as a result of being exposed to wildlife. (Garland-Lewis *et al.* 2017).

Carers need to rely on personal resilience to deal with traumatic events, such as an animal dying, having an animal in care attacked by a predator or requiring an animal to be euthanased because it is unsuitable for release. These coping strategies can be likened to related needs in veterinarians (Rollo 2015) and volunteers who care for foster children, the disabled or elderly (Pickin *et al.* 2011; Li *et al.* 2014; Mishra *et al.* 2016).

During the time wildlife carers have responsibility for an animal, there is the potential for many events that can compromise their mental wellbeing. These can relate to the animal dying, becoming ill or suffering an injury and having to enter veterinary care, or even accidentally escaping. The carer may become unwell, have a personal crisis or a demanding family event, or be attacked by an animal in their care. They may be told to toughen up by friends or other carers if they are showing emotion towards an animal dying or leaving. Additional to these stressors, there is the knowledge that the animal must be released with no certainty of survival. After release, the animal may be shot or returned to care after having been injured. Volunteer respondents to a recent survey (PwC 2016: p. vii) reported that 'in their experience, both complacency and ignorance of the enormous value volunteers contribute results in a lack of regard of volunteers as strategic assets'. Similarly, an earlier study of wildlife carers (Guy and Banks 2010), revealed that carers perceived government attitudes towards wildlife rehabilitation as more negative than positive. Wildlife carers do not even have the comfort of knowing that their efforts are serving any useful purpose, other than the personal satisfaction of caring. Even though monitoring of released animals is recommended by the RSPCA Australia (RSPCA 2017), there is an almost total lack of post-release monitoring, supervision or data collection (Guy and Banks 2010). However, when reared individuals are of a threatened or endangered species, they are usually identifiable by microchip,

tracking collar, tag or distinct coat markings. This enables some post-release monitoring and the contribution made to wildlife conservation can be estimated. Well-trained volunteer carers are expert in being available to undertake this rearing and release work and receive the reward of knowing this contribution is valued. Another valuable contribution wildlife carers can make is as environmental educators (Croll 2011). They have the ability and expertise to work through environment education centres to provide talks to schools, clubs and community groups. This adds to the self-worth felt by carers as well as educating others about the environmental effects of roadkill on native animals.

The stressors mentioned previously may expose wildlife carers to the risk of compassion fatigue and considerable grief of different kinds. When relationships with animals are believed to be inferior to human relationships this can be problematic at times of a loss (Hafen *et al.* 2017) The question of whether certain kinds of grief can be applied equally to the loss of an animal to which a person has bonded merits consideration. Support for this prospect lies in attachment theory and in how wildlife carers view the animals for which they care. Furthermore, there are theoretical arguments and empirical evidence that indicate attachment theory offers the means to examine human-animal bonds, and that humans can form attachment bonds with animals that are similar to exclusively human attachment bonds. By way of examples, Beck and Madresh (2008) and Zilcha-Mano (2017) developed questionnaires based on a validated human relationship questionnaire (RQ) (Bartholomew and Horowitz 1991) and a revised version of the experiences-in-close-relationships (ECR-R) questionnaire (Fraley *et al.* 2011) to examine, first, human relationships with animals as distinct from those with human partners and, second, the attachment quality of human-animal attachment. Zilcha-Mano (2017) concluded that human-animal bonds meet the four prerequisites of attachment bond, namely proximity seeking, safe haven, secure base and separation distress, and that animals can therefore be viewed as attachment figures. Kurdek (2009) compared the way owners used their dogs as a safe haven as opposed to other key attachment figures, such as spouses, parents and friends. From these studies, it was concluded that humans can form attachment bonds with animals in ways that are consistent with the literature on attachment theory.

Because attachment brings with it the risk of loss, and therefore grief, the links among the three have been demonstrated in theories of grief and mourning (Weiss 1988; Parkes *et al.* 1993; Shaver and Cassidy 1999). Archer (1999) argues that grief is a natural reaction to losses of many kinds, even the death of an animal. He brings together experimental psychology, ethology and evolutionary psychology to demonstrate this. This definition of grief, as a reaction to a loss, is supported by more recent authors (Morris 2013; Rainer 2013; Winokuer *et al.* 2016). Worden (2002) has argued that the strength of one's attachment to another, the security of the attachment and the ambivalence in the relationship are all factors that will affect the grief reaction to the loss of that other.

It may seem perverse to suggest that wildlife carers could suffer from more types of grief than someone experiencing the death of a spouse. However, this is possible not least because there are many different experiences of loss that can occur

during the time a wildlife carer is rescuing, rehabilitating and releasing an animal, whereas the death of a spouse is a single event. Feelings of loss are very personal, and only the affected individuals know the strength of relevant attachment bonds and hence the size of a loss. However, it can be seen from Table 6 that four of the major types of grief, anticipatory, disenfranchised, traumatic and unanticipated are proposed for both the death of a spouse and the rearing of an animal for release. It is beyond the scope of the current review to attribute degree of loss and grieving experienced by a wildlife carer. This is an area for further research. It would require the use of a validated grief instrument, suitably modified to apply to those who care for rescued wildlife, to be administered by way of an individual questionnaire survey or interview. This would then need to be evaluated to quantify the degree of grief experienced by carers resulting from the different events that occur during the rescue, rehabilitation and release of orphaned wildlife.

The death of an animal in care could be a trigger for several forms of grief, particularly if sudden, or if the carer is inexperienced. Abbreviated grief (Appendix 1a) is a short-lived but normal form of grief. The grieving process is shortened because the role of the deceased animal is immediately filled by another joey, and because there has often been little or no attachment to the deceased animal (Averill 1968; Irving *et al.* 1999). However, chronic grief (Appendix 1e) is a severe grief reaction that may have features in common with most early stages of grief, but is one that does not abate and can last for an extended period and fail to reach a conclusion. Carers can experience extreme distress over the death of an animal and make little or no progress in coping with normal living (Lasker and Toedter 1991; Middleton *et al.* 1996; Bonanno and Kaltman 2001). This form of grief can be maintained by feelings of insecurity and insecure attachment to the deceased animal (Middleton *et al.* 1996). For an inexperienced carer, especially one who is psychologically unprepared, experiencing the death of an animal for the first time is likely to result in prolonged grief (Appendix 1n). The carer could be incapacitated by grief and daily function might be impaired on a long-term basis. The carer might spend much time contemplating the death, longing for reunion, and be unable to adjust to life without the animal (Barnes *et al.* 2012; Kersting *et al.* 2013). In a similar way, the sudden death of an animal can trigger unanticipated grief (Appendix 1q). This form of grief is characterised by great difficulty in accepting the loss and is accompanied by overwhelming feelings that could result in the carer becoming less able than normal to function in various areas of their daily life (Parkes 1986). Although affected carers could intellectually acknowledge the death, they would often have great difficulty in accepting the loss, due to it being sudden and unexpected. In this situation, grief symptoms will tend to persist much longer than normal grief reactions (Waskowic and Chartier 2003). This could damage the affected carer's adaptive capabilities and require a complicated recovery. If a carer experiences a second loss while still grieving the first (Pivnick 2011), then the two losses become cumulative (Appendix 1g), compounding the grief (Marino 1998). Delayed grief (Appendix 1h) may occur when a carer, consciously or subconsciously, avoids the reality and pain of a loss and suppresses feelings of grief outside the normal immediate

timescale after an animal's death. The grief may later be triggered by an event related to the original loss, such as finding the pouches in which a joey was reared or a bottle from which it was fed (Bonanno *et al.* 2002; Claxton and Reynolds 2012).

Events external to the actual caring for the animal can also trigger grief, which is said to be disenfranchised (Appendix 1i), when feedback from a support group or friends (however inadvertently) makes carers feel that their loss, and/or their grief, is invalidated and insignificant (Doka 1989). Consequently, such grief cannot be acknowledged openly and has a depth that is not socially recognised. For example, displaying certain characteristics, such as crying uncontrollably over the death of an animal and placing flowers on its grave, could be regarded as not socially recognised and so has a silencing effect on the carer (Doka 1989). This grief could be triggered by remarks by others about the need for carers to toughen up, be less emotionally weak or even to care less for an animal (Raup and Myers 1989). Distorted grief (Appendix 1j) might be triggered when a carer must return an animal to authorities in the knowledge that it is extremely unlikely to survive if subjected to immediate placement into the wild (so-called hard release). Extreme, intense or atypical reactions to this event could cause carers to show unusual behaviour and self-destructive actions (Middleton *et al.* 1993). Anger and hostility towards oneself or others are common in instances of distorted grief (Remondet and Hansson 1987).

Another form of grief typically lacks clarity and is termed ambiguous (Appendix 1c). It can lead to carers holding different views about what has been lost (Lagoni *et al.* 1994). Individuals and those around them may question whether a real loss has occurred or whether the loss is of a scale sufficient to justify strong emotional responses, such as may arise with disenfranchised deaths (Boss 1999; Hollander 2016). When an animal is released to the wild and is unable to be tracked, carers are unlikely to know what happens to this creature they have been committed to for up to 2 years. A sense of grief, termed unresolved grief (Appendix 1r), could develop and may be punctuated with hope that the animal will survive and be identified at some time in the future (Boss 1999; Barton Ross and Baron-Sorensen 2007). There may also be an element of self-doubt or guilt in believing that it is best for the animal to be returned to the wild. The resolution of grief could be elusive if carers cling to the hope that information will come to light that their animal has survived (Middleton *et al.* 1993; Boss 1999).

There are other grieving phenomena that can be experienced internally by a carer. Absent (Appendix 1b) and inhibited grief (Appendix 1l) can stem from denial or inhibition. Absent grief may be demonstrated by the carer behaving as though nothing has happened. The affected carer typically shows no feelings of grief and become detached from reality as if the event never occurred (Middleton *et al.* 1996; Bowlby 1998; Solomon and Gupta 2014). This is similar to inhibited grief where, again, the carer shows no outward signs of grief, but where symptoms can last for an extended period. Physical problems, such as lack of energy, headaches, gastrointestinal symptoms and chest pain, might develop if carers deny themselves the opportunity to experience the pain of grief directly (Middleton *et al.* 1998). It is possible for grief reactions to impair normal functioning,

but a carer might fail to associate these signs with a loss. Symptoms are often masked as either physical symptoms or other maladaptive behaviours (Bonanno and Kaltman 2001), so this is termed masked grief (Appendix 1m).

Other forms of grief can occur over many months or years. Anticipatory grief (Appendix 1d) can happen when a carer believes some kind of loss will eventuate. The loss is not necessarily caused by anticipating a death or injury to an animal that is not healing and thus likely to die. By way of an example, carers may feel this grief before an animal is due to be released, particularly if they do not know what will happen to it. This grieving progress could continue for an extended period and so be emotionally draining because the latency before the loss is unpredictable (Rando 1986; Middleton *et al.* 1993; Simon 2008; Holley and Mast 2009). Normal grief responses experienced in combination with traumatic distress (e.g. due to some frightening, horrifying, unexpected, violent or traumatic event) can trigger traumatic grief (Appendix 1p). An example could be when animals placed in an enclosure to prepare them for release to the wild are killed by predators or are shot. The distress caused could be extreme enough to impair daily functioning and trigger reactions such as avoiding people, places or activities that remind the carer of the animal, or experiencing unusual levels of sleep disturbance, loss of interest in work, social caretaking or recreational activities to a maladaptive degree (Prigerson *et al.* 1999; Levinson and Prigerson 2000; Lobb *et al.* 2006; Bonanno and Mancini 2008; Kersting *et al.* 2013).

Although the mental state of wildlife carers can be adversely affected when the day-to-day caring for an animal comes to an end, and the animal is released, there can also be relief and happiness at the success of getting the animal to this stage and ready for release. The situation can be compared with the time when children leave home and the effect this has on their parents. The void left by the departure can cause loneliness and grief. The effect of the adjustment needed and satisfaction with life can be significant (Raup and Myers 1989; Mitchell and Lovegreen 2009; Bouchard and McNair 2016). Accordingly, it is wise to prepare emotionally for the departure and wildlife carers can adopt strategies similar to those suggested to human carers to reduce the possibility of grief and be able to experience a positive outcome (Hebert *et al.* 2006; Holm *et al.* 2015).

Other factors that may cause distress to carers

Charles Figley's original general description of compassion fatigue (Figley 1995) has been applied to many professions, including healthcare professionals (Meadors and Lamson 2008), psychotherapists (Figley 2002), social workers (Bourassa 2012), foster parents (Blanchette 2011) and family caregivers (Perry *et al.* 2010), demonstrating how widespread this phenomenon can be. Compassion fatigue in the animal care community is described as 'exhaustion due to compassion stress, [and] the demands of being empathic and helpful to those who are suffering' (Figley and Roop 2006: p.12). The result can be disruptive, depressive and irritating, and can lead to occupational burn out. This is a situation where wildlife carers become physically and emotionally exhausted, usually after prolonged stress, frustration and sleeplessness, and become

unable to function (Rank *et al.* 2009; Moore *et al.* 2014; Galazka 2017).

Even though they are volunteers, wildlife carers are subject to government authority and policies. (Australian Capital Territory Parliamentary Council 2014; New South Wales Government 2010; Queensland Government 2006; Western Australian Government 1970; South Australian Government 1972; Tasmanian Government 2002; Victorian Government 1975; Northern Territory Government 2014). Many of them find this a problem. When regulations are so prescriptive that monitoring of compliance is virtually impossible, or the expertise to make assessments of behavioural suitability for return to the wild is unavailable, those who do try to comply with regulations feel let down when others are not being required to comply (Bardach and Kagan 1982; Nie 2008). This can lead to conflict both between individual carers and within organisations (Jacobs 2017).

All wildlife carers expend time, money and effort in rearing orphans or rehabilitating injured animals. Depending upon state regulations, they are mandated to release the animals back to the location where they were found, once they have been reared. For example, Section 12.2.1.4. of the NSW Code of Practice for Injured, Sick and Orphaned Protected Fauna (New South Wales Government 2010: p.20) states 'If there is no information about where fauna was found, it must not be released.' Also, Section 7.1.1.2 p.8. states: 'Fauna must be euthanased when there is no suitable release location'.

These release sites may be close to farmland or a settlement where native animals are regarded as pests. In NSW in 2016, 107 687 native animals and birds were killed by property owners using an 's121' licence (intended to control native animals if they are causing damage or economic hardship on a property). Additionally, the NSW Office of Environment and Heritage issued permits for the killing of 170 290 eastern grey kangaroos, 308 swamp wallabies and 136 common wombats (NSW Parks and Wildlife Service 2017, pers. comm.). In the same period, 14 004 marsupial species were returned to the wild by wildlife carers who were members of the NSW WIRES (WIRES, 2017, pers. comm.). By way of comparison, in Victoria in 2011, the figure for mammals returned to the wild was 6 442 (Department of Environment, Land, Water and Planning, 2017, pers. comm.). Regardless of interstate differences in numbers, the paradox here is that animals are being rescued, raised for release and returned to the site of the traumatic event that brought them into care at the same time as similar species are being killed under licence. This can be challenging for volunteers, whose primary objective is the welfare of animals.

Wildlife rehabilitation is defined as 'the managed process whereby a displaced, sick, injured or orphaned wild animal regains the health and skills it requires to function normally and live self-sufficiently' (Molony *et al.* 2006: p. 530). There are notable success stories of hand-reared or captive-bred animals being successfully reintroduced to the wild, often featuring wombats (Saran *et al.* 2011) and Tasmanian devils (Rogers *et al.* 2016). However, many reintroductions are unsuccessful or meet limited success. For example, between 1972 and 1988 six separate attempts to reintroduce threatened wallabies (Marsupialia: Macropodoidea) in areas of Western Australia

and New South Wales all ended in failure (Short *et al.* 1992; Priddel and Wheeler 2004; Short 2010; Moseby *et al.* 2011). After a comprehensive evaluation of 380 translocations in Australia, involving 102 species (beginning with koala to Phillip and French Islands in Victoria in the 1880s to 125 translocations since 2000), a survival rate of 54% was recorded (Short 2010). There is no requirement under any state legislation for animals to be reliably identifiable (by means of microchipping, tagging or branding) either during care or before release. In contrast, one of the main reasons that wildlife carers undertake the rehabilitation of injured and orphaned animals is for conservation purposes (Guy and Banks 2010). Whether this aim is being satisfactorily fulfilled is impossible to ascertain without reliable data from post-release monitoring. A system of individually identifying animals from the moment they enter care would enable better governance during the rehabilitation process and informed decisions about future release activities. A simple microchip would enable any road kill or culled animal to be scanned and identified as a hand-raised orphan or not. The cost of approximately \$20 per animal is one that could be met by state or federal authorities so as not to increase the financial burden on carers.

The problem presented by roadkill and other anthropogenic and natural events that result in orphaned and injured animals is a national one. A priority recommendation for future research would be two national roadkill survey days separated by 3 months with citizen scientists using a suitable smartphone or tablet app to record roadkill, so that temporal and spatial data are confined to these days. A national approach that includes a consensus of best practices for training wildlife carers, raising and rehabilitating orphaned and injured animals, monitoring release outcomes and financial and counselling support would increase the professional standing of carers and, through them, outcomes for the animals for whom they care.

The need for volunteers in contexts beyond wildlife care is increasing, with 86% of organisations that use volunteers stating the need for more personnel (PwC 2016). In 2014, the Australian Bureau of Statistics recorded the first decline in both men and women volunteering since records began. The social capital of Australia has declined from its 1967 situation, when 33% of Australians were members of organisations such as Rotary clubs, Lions clubs and the Scouts, to just 18% by 2004 (Caneva 2015; Cowlshaw *et al.* 2010).

Animal welfare ranks fourth among sectors in which volunteers would be most interested to volunteer (PwC 2016). The number of wild animals presented to the RSPCA Australia has increased from 8310 in 1998–99 to 25 568 in 2015–16. Clearly, as the number of wildlife requiring treatment increases, so does the need for wildlife carers. In NSW, WIRES reports that its membership numbers are presently 2333 and that these numbers fluctuate between 2100 and 2500 as new volunteers are recruited and trained (WIRES, 2017, pers. comm.). This illustrates a considerable turnover in volunteer numbers and the requirement for constant management of recruitment. Should recruitment become unsustainable then pressure on the remaining experienced carers will continue to build as the workload increases.

One way to ease the workload for wildlife carers would be to reduce the number of animals requiring rescue and rehabilitation.

There are several methods by which this could be achieved, one being the adoption of a non-intervention or euthanasia policy for all or some injured or orphaned animals but, as discussed earlier with the case of Harambe, the gorilla at Cincinnati zoo, this would be unlikely to meet with general approval from the public. From an Australian perspective, possibly the first public reaction on a conservation issue related to animal culling occurred in Queensland in August 1927. The government passed legislation that allowed the killing of Koalas and 600 000 were killed in the following month. The public backlash led to the killing being banned. Roe (2017). There are many recent examples in Australia where animal advocates and activists have managed to focus public attention on the issue of animal welfare and gain political consensus. This sensitivity is highlighted in the following statement of the Department of Territory and Municipal Services Australian Capitol Territory (2017: p. 142): 'It is inevitable that kangaroo management in the nation's capital will be affected by 'animal rights' campaigns against any management actions that involve the killing of kangaroos'. Similarly, a plan to cull koalas on Kangaroo Island in 2015 was cancelled by the South Australian government after a public backlash. The AKF's stance on koala relocation and culling (Australian Koala Foundation 2017: p.1) states it 'will never condone the culling of koalas or any other native animal'. This position is likely to be supported by the nation's 15 600 wildlife carers (Table 2).

Another option to ease the workload for wildlife carers is to recruit more of them, or reduce the number leaving. Similarly, a reduction in roadkill (and therefore the need to rescue orphans) would have the effect of reducing the burden on wildlife carers. This is an area where a national research approach on roadkill mitigation measures could be highly beneficial.

Conclusion

The physical, financial and mental contributions made by wildlife carers are considerable. The current review reveals that wildlife rehabilitation in Australia is a major operation undertaken by volunteers acting individually or as part of an organisation. It is managed on a state-by-state basis, each with its own set of rules and regulations, and by more than 200 organisations and by individuals acting alone, so its operation is fragmented. Future research opportunities should focus on a national system of licensing and training carers and on an overall plan for the way animals are prepared for release on a species-by-species basis. A system of individually identifying animals from the moment they enter care would enable better governance during the rehabilitation process and informed decisions to be made about future release activities. As roadkill increases, volunteering declines and financial costs increase, those volunteers still acting as wildlife carers are likely to experience increasing workloads, and with that, increasing financial, mental and physical stressors.

The wildlife carers who manage Australia's injured and orphaned native animals are a national asset that requires strategic nurturing with empathy, understanding, financial and psychological support if it is to remain viable and sustainable. The skills learned in this process often contribute to the success of captive breeding and may be the salvation of many animal species threatened with extinction in the future.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix 1. General definitions of grief

There are no standard definitions for types of grief. The following are a consensus drawn from several authors (Archer 1999; Worden 2002; Bryant and Peck 2009; Wilson 2013; Boss and Yeats 2014).

- (a) *Abbreviated*. A short-lived form of grief. The grieving process often seems shorter than for normal grief because the role of what is lost is immediately filled by someone or something else.
- (b) *Absent*. This is characterised by the bereaved acting as though nothing has happened for a period up to approximately a week.
- (c) *Ambiguous*. The losses are hard to define and therefore also hard to identify. Ambiguity makes it hard to grieve the loss fully because it seems so inconsequential and insignificant.
- (d) *Anticipatory*. The reaction to an expected loss and grief begins once it is accepted and understood that a loss will occur.
- (e) *Chronic*. These are strong grief reactions that do not subside and last over a long period. The person is continually experiencing extreme distress over the loss with no progress towards feeling better or improving functioning.
- (f) *Collective*. Grief reactions that are felt by a collective group such as a community, society, village, or nation.
- (g) *Cumulative*. When a second loss is experienced while the affected individual is still grieving a previous loss.
- (h) *Delayed*. Lack of time to mourn when a loss occurs means grieving is delayed and symptoms and reactions are not experienced until an extended period has elapsed.
- (i) *Disenfranchised*. This is a term describing grief that is not acknowledged by society. Even widely recognised forms of grief can become disenfranchised when well-meaning friends and family attempt to set a time limit on a person's right to grieve.
- (j) *Distorted*. This is characterised by intense, extreme, or atypical reactions to a loss
- (k) *Exaggerated*. This type occurs when there is a cumulative effect of losses.
- (l) *Inhibited*. This is a form of unresolved grief where the bereaved person displays no outward signs of normal mourning for an extended period.
- (m) *Masked*. These are reactions that impair normal functioning even though the individual is unable to recognise these symptoms and behaviours are related to the loss.
- (n) *Prolonged*. Reactions that are prolonged and intense. The griever is incapacitated by grief and daily function is impaired on a long-term basis.
- (o) *Secondary*. This occurs when a loss affects many areas of life, creating multiple losses stemming from the primary loss.
- (p) *Traumatic*. Normal grief responses experienced in combination with traumatic distress suffered as a result of a frightening, horrifying, unexpected, violent and/or traumatic event.
- (q) *Unanticipated*. These reactions result from an entirely unexpected sudden loss.
- (r) *Unresolved*. This grief lasts longer than usual and does not go away.