Roo the day: evaluating the ShuRoo for prevention of macropod-vehicle collisions

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ABSTRACT

Collisions between vehicles and macropods pose problems for road safety, animal welfare and wildlife conservation in Australia. We tested the ShuRoo, which is marketed specifically to deter kangaroos from approaching vehicles. We recruited 18 fleet operators with vehicles travelling consistent routes over long distances in rural areas: 59 vehicles fitted with ShuRoos and 40 vehicles without ShuRooss to act as controls. Drivers kept a log of collisions with macropods over an average distance travelled of 46,131 km. The overall mean rate of collisions with macropods was 1.16 per 100,000 km, with no significant difference between vehicles with a ShuRoo (1.32 ± 0.51) versus those without the device (0.68 ± 0.39). Drivers have the capacity to change their behaviour as a coping strategy to the presence of wildlife on the road, but risk a rebound effect if they believe the ShuRoo manufacturer's claims and do not modify their driving behaviour to match the context. Rather than retro-fitting an ill-conceived device like the ShuRoo, an integrated, inter-disciplinary approach is needed to resolve the pervasive problem of macropod-vehicle collisions.

Key words: wildlife-vehicle collisions, acoustic deterrent, ultrasonic signal, signal detection, self-report diary, behavioural response, driver response, rebound effect, roadkill.

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Introduction

Collisions between vehicles and macropodid marsupials, particularly the larger kangaroo species, pose a vexing management problem in Australia (Lunney 2013, Bond and Jones 2014). Six species are most often involved in collisions: eastern grey kangaroo (*Macropus giganteus*), western grey kangaroo (*M. fuliginosus*), red kangaroo (*Osphranter rufus*), common wallaroo (*O. robustus*), red-necked wallaby (*Notamacropus rufogriseus*), and swamp wallaby (*Wallabia bicolor*) (Coulson 1997; Lee *et al.* 2004; Rowden *et al.* 2008). Collisions with macropods can cause significant damage to vehicles, resulting in a total repair cost of $28 million across Australia annually (Huddle 2019). Wildlife carers also incur great personal and financial cost in their efforts to rescue, rehabilitate and release many orphaned young macropods (Englefield *et al.* 2018). Injuries to the vehicle occupants are likely under-reported, but are apparently increasing (Ang *et al.* 2019). Human injuries are generally only minor (Abu-Zidan *et al.* 2002), although fatalities can occur, typically when the driver tries to avoid the macropod on the road and then has a secondary collision with a solid object such as a tree (Rowden *et al.* 2008; Ramp and Roger 2008).

The consequences for the macropods involved in collisions are much less clear. There has been no systematic research on the success of efforts to rescue pouch-young. Generally, only incidents that result in human injury, or enough damage to a vehicle to warrant an insurance claim, are reported (Ramp and Roger 2008). Similarly, studies that report the frequency of carcasses along roads acknowledge that the true number of deaths is underestimated because injured animals may die away from the road verge, or their carcasses may be obscured by vegetation, or later removed by people or scavengers (e.g., Taylor and Goldingay 2004; Ramp and Roger 2008). Animal-vehicle collisions also pose a conservation threat to some rare species, such as the Proserpine rock-wallaby (*Petrogale persephone*) (Johnson *et al.* 2003) and Lumholtz's tree-kangaroo (*Dendrolagus lumholtzi*) (Shima *et al.* 2018). Furthermore, macropods are frequently injured in collisions, raising animal welfare concerns.

The risks of collisions between vehicles and macropods, as well as other wildlife species, have led to interest in a range of primary safety measures, which are designed to reduce the probability of a collision (Gunson and Teixeira 2015; Rytwinski *et al.* 2016). Macropod movements can be effectively blocked by some types of roadside fences (Bond and Jones 2014) and macropods will use overpasses and underpasses to cross roads (e.g. Taylor and Goldingay 2004; Bond and Jones 2008; Chachelle *et al.* 2016). However, the high cost of fencing and crossing structures restricts their use to major freeways (Bond and Jones 2014), giving no protection along the many secondary roads where most collisions with macropods occur (Burgin and Brainwood 2008; Lee and Croft 2008; Ramp and Roger 2008). Similarly, warning signage is rarely effective for reducing collisions with wildlife, primarily because drivers attentiveness soon declines (Huijser *et al.* 2015). For example, standard kangaroo warning signs were ineffective at reducing the incidence of eastern grey kangaroo road-kills in a Before-After-Control-Impact study (Coulson 1982).

Another primary safety approach is deterrence, which aims to discourage animals from entering the roadway and/or encourages them to leave. Wildlife reflectors are designed to reflect the headlight beam of a vehicle towards the roadside verge and discourage road crossing. However, reflectors have been shown to be ineffective for European and North American deer, which could not detect the stimulus, habituated to the stimulus, or responded by 'freezing' on the road (D'Angelo and van der Ree 2015; Benten *et al.* 2018). Similarly, reflectors did not reduce incidence of road-kills of macropods in a Before-After-Control-Impact study in Victoria (Aspinall 1994) and captive macropods showed little or no response to reflectors along a simulated roadway (Ramp and Croft 2006). Trials of the 'virtual fence', with speaker units along the roadside, have yielded conflicting results: Fox *et al.* (2019) reported a 50% reduction in roadkills of macropods in northern Tasmania (but see Coulson and Bender 2019), whereas Englefield *et al.* (2019a) found no effect on macropods in southern Tasmania. Vehicle-mounted whistles, which are passively driven by airflow, are not effective in reducing collisions with wildlife (D'Angelo and van der Ree 2015). These whistles could not be detected above vehicle noise (Scheifele *et al.* 2003) and, unsurprisingly, did not alter the behaviour of deer (Romin and Dalton 1992) or macropods (Magnus *et al.* 2004).

An active acoustic device, the ShuRoo (ShuRoo Operations Pty Ltd, Brisbane, Queensland), is marketed in Australia specifically to deter kangaroos from roadways (Domico 1993; Gore 1994). The ShuRoo Mk 1 was released in 1985. It comprised a signal generator and two speakers covered with a fine mesh grill, all encased in a metal housing (Fig. 1a). This model was claimed to produce a noise level of 130 dB, with the signal forming a 'pear shaped sound pattern' that extends 400 m ahead of the vehicle, and 50 m either side (Gore 1994). The high frequency component of the signal was said to warn kangaroos of impending danger, so they would flee from the path of the vehicle (Gore 1994). Despite these claims, the effectiveness of the ShuRoo in deterring free-ranging macropods from roadways has never been scientifically evaluated. Our study aimed to test the efficacy of the ShuRoo. We compared the rate of vehicle collisions with macropods, by sampling vehicles that travelled long distances with and without the ShuRoo.

Methods

We identified possible users of the ShuRoo through the Yellow Pages, internet listings, list servers of the Australasian Wildlife Management Society and Ecology Society of Australia, and through subsequent referrals. We sought private companies or government departments that operated fleets of similar vehicles travelling consistent routes over long distances in rural areas. We targeted bus and truck companies in particular, but a range of other operators such as ambulance, police, local council and state wildlife agencies also met these criteria. We attempted to pair vehicles that were fitted with a ShuRoo unit, and other vehicles that had no ShuRoo or other sonic deterrent device fitted, ideally within the same fleet and operating in the same areas.

We initially contacted fleet operators either by letter, telephone, email, or facsimile. We made the first contacts in 1997 and continued until late 2000, contacting a total of 278 operators. At initial contact, we outlined the project and requested participation in a field survey to evaluate the efficacy of the ShuRoo, but offered no financial remuneration. It was difficult to locate and then recruit fleet operators into the survey: many replied that they were too busy or could not provide access to appropriate staff within the organisation, and some operators refused to participate because of their previous negative experience with the ShuRoo. Many of the fleets that used the ShuRoo had them fitted to all their vehicles, resulting in an absence of controls; we also found it hard to convince other operators, who were not using the ShuRoo, of the benefits of participating in the survey to balance the design.

When each fleet operator agreed to participate, we sent a letter outlining the purpose of the study, and a sample of the travel log data sheet. We made a follow-up telephone call shortly after to ensure the operator was still willing to participate, and to acquire information about the number of vehicles that would be involved and how many were fitted with the ShuRoo. The fleet manager was generally the point of contact. Managers typically expressed enthusiasm when first contacted, but some withdrew from the survey when they or their drivers found the task too onerous. Several managers withdrew because their drivers refused to record their odometer readings. In the early stages of the project we also visited some fleet depots to outline the project directly to the drivers, and to obtain their feedback on methods for recording data. In August 2000, we sent an information sheet to all participants, which outlined the project, introduced the research staff involved, summarised the results to date and sought contacts for potential new participants.

A total of 31 fleet operators agreed to participate in the survey, although we ultimately received data from only 18. The survey ran from August 1999 to January 2001, and operators joined and left the survey over this time. Their vehicles and the routes they covered included heavy trucks on interstate routes travelling as far as Queensland from Victoria, buses from Melbourne to regional centres in Victoria and Southern NSW, ambulances and police vehicles in western Victoria, passenger vehicles operated by two rural shire councils,

Figure 1. Vehicles fitted with the ShuRoo: (a) Mark 1, (b) Mark 5. Note the powerful driving lights also fitted to both vehicles.

and a rural taxi company. Each operator was based in one of four states, most being based in Victoria (Table 1). A total of 59 vehicles were fitted with ShuRoo (treatment) and 40 vehicles without a ShuRoo (control) (Table 1). All but two of the participating fleets included at least one vehicle fitted with a ShuRoo, but many also had vehicles without one. All ShuRoo fitted to vehicles were purchased, installed and maintained by the fleet operators. Some vehicles were reported to have been driven with the ShuRoo not functioning during part of the road survey, so we transferred them to the control group for that period. We did not ascertain the model of ShuRoo fitted to vehicles, or make any acoustic measurements of the ShuRoo units.

Table 1. Fleet operators recruited in each state, and the number of vehicles in each fleet with and without a ShuRoo fitted, between August 1997 and November 2000.

	Number of vehicles	
	With ShuRoo	Without ShuRoo
New South Wales		
Shire Council A	2	2
Taxi Service	3	1
Queensland		
Freight company A	2	
Freight company B	1	
Victoria		
Bus service	8	
Freight company C	15	24
Freight company D	2	
Freight company E	1	
Freight company F	2	
Police force A	1	1
Police force B	3	
Police force C		2
Shire council B	3	6
Shire council C	10	2
Shire council D	3	
Western Australia		
Freight company G	2	1
Mining company A		1
Mining company B	1	
TOTAL	**59**	**40**

Through the fleet managers, we asked drivers to keep a log of the number of collisions with kangaroos and wallabies over the total distance they travelled. Drivers were instructed to fill out the log soon after any collision so that their recall was as accurate as possible. The distance travelled was calculated from the start and finish reading on the odometer. To reduce the drop-out rate, we minimised the amount of data each driver was required to record. We did not ask drivers to specify the route travelled or their driving behaviour, or to distinguish between macropod species, but we did request copies of their data sheets once per month, or whenever collisions occurred. Our method of acquiring these data was flexible (email, telephone or facsimile) to make this process as convenient as possible for the drivers and managers. Data were collected indiscriminately over a range of seasonal conditions, moon phases and times of day that are known to influence the rate of macropod collisions (Coulson 1982, 1989, Lee *et al.* 2004, Osawa 1989).

We treated each vehicle as an independent sampling unit, regardless of type, distance or route. We compared treatment *versus* control vehicles in terms of their duration of involvement in the study, their cumulative distance travelled, and their collision rates (expressed per 100,000 km travelled). We used the non-parametric Mann-Whitney *U* Test, because the distributions of these three variables were negatively skewed and their variances were unequal.

Results

Overall, the 99 vehicles involved in the survey travelled for a total of 15,577 days and covered an aggregate distance of 4,204,378 km. The duration of involvement in the study by an individual vehicle ranged from 16 to 895 days, and the distance travelled by each vehicle ranged from 1,105 to 175,489 km. There was no difference between vehicles with ShuRoo fitted and control vehicles (without ShuRoo) in either duration of involvement or distance travelled (Table 2).

Only 16% of the vehicles in this study were reported to have collided with a macropod over the survey period. The overall collision rate was 1.16/100,000 km. However, there were two obvious outliers in this data set, both for vehicles fitted with a ShuRoo: a Victorian-based driver reported hitting 39 kangaroos in one night, and a Queensland-based driver reported 25 hits in one night. When we excluded these outliers, the overall days of travel reduced to 15,452 days and the aggregate distance reduced to 4,073,425 km, with an overall collision rate of 1.08/100,000 km. Notably, there was no difference in the collision rate of vehicles with and without a ShuRoo (Table 2).

Discussion

The manufacturer of the ShuRoo does not provide any evidence in support of their claims about the effectiveness

Table 2. The duration of involvement, distance travelled and macropod collision rate for vehicles with and without a ShuRoo fitted, between August 1997 and November 2000.

	With ShuRoo (n = 59)	Without ShuRoo (n = 40)	Test statistic (two-tailed)	P value
Mean (± SE) survey duration (days)	161 ± 14	153 ± 23	U = 800	0.453
Mean (± SE) distance travelled (km)	46131 ± 5383	37067 ± 4728	U = 1065	0.582
Mean (± SE) macropod collision rate (per 100,000 km)*	1.32 ± 0. 51	0.68 ± 0.39	U = 1055	0.373

* Excluding two outliers (n = 57 with ShuRoo)

of the ShuRoo (ShuRoo 2021). Instead, their claims appear to be based on personal observations and testimonials (Domico 1993). Vivid accounts such as these can be highly persuasive for potential customers (Hornikx 2005; Hoeken and Hustinx 2009), but anecdotal evidence is also notoriously unreliable. In contrast, we conducted a large-scale road test of the ShuRoo using a planned and paired trial to collect reliable and objective data from users of the device. This allowed an independent and scientific evaluation of the effectiveness of the ShuRoo in reducing collisions with macropods.

Our study ran for 19 months, with each vehicle involved for an average of 5 months. The study thus encompassed all seasons and lunar phases, which are known to affect the likelihood of macropod-vehicle collisions (Bond and Jones 2013). The 99 participating drivers would have encountered a wide range of driving conditions during this period as they covered the aggregate distance of over 4 million km. The average distance travelled by vehicles in this study (42,468 km) greatly exceeded the average distance of 14,800 km for vehicles registered in Australia in the corresponding period (Australian Bureau of Statistics 2000). Previous studies of interactions between vehicles and wildlife in Australia have either recorded carcasses along the roadside (e.g., Klöcker *et al.* 2006; Mathews 2019) or compiled records of collisions from wildlife rescuers (Visintin *et al.* 2017) or hospital admissions (Abu-Zidan *et al.* 2002; Ang *et al.* 2019). Instead, we adopted a self-report diary method, which is commonly used in studies of driving dynamics (Agramunt *et al.* 2017). Self-reporting by drivers has also been used to record collisions between wildlife and trains in Canada (Muzzi and Bisset 1990) and Australia (Visintin *et al.* 2018). There may be inaccuracies in self-reported data: participants may exaggerate due to bravado, or under-report collisions due to embarrassment, or make counting errors, or simply forget incidents (Agramunt *et al.* 2017). The two outliers in our study probabaly over-reported their incidents, although their motiviation for doing so was unknown. Nonetheless, self-reporting is an efficient way of sampling many drivers over a wide range of space and time, resulting in an extensive and realistic road trial of the ShuRoo.

Despite the large sample of vehicles, their lengthy involvement and their extensive distance travelled, there was no significant difference between vehicles fitted with a ShuRoo and those without in terms of their collision rate with macropods. We conclude, therefore, that the ShuRoo does not lower the likelihood of colliding with a macropod on the road. This conclusion prompts a closer examination of the claims made by the manufacturer. Five ShuRoo models have been produced to date. There have been obvious changes to the external housing in that time (Fig. 1b), but no technical specifications are available for any model. However, the manufacturer still makes essentially the same claims about their performance (ShuRoo 2021). For example, the manufacturer claims that 'Any kangaroo in the ShuRoo range of projection… will be alerted to your approach and likely move in the opposite direction, out of the projection range or simply stay put where it is and watch you safely drive by' (ShuRoo 2021). We first consider the acoustic properties of the signal emitted by the ShuRoo, then the perceptual abilities and responses of the target species, and finally the behaviour of drivers.

Independent acoustic testing of the ShuRoo showed that the signal had a mix of frequencies, descending from 23.6 kHz (ultrasonic) to 14.6 kHz (audible) (Bender 2001). It has long been known that ultrasonic signals attenuate rapidly in air, due to spread, scatter and absorption effects (Schilling *et al*. 1947). The lower frequencies of the signal would be less affected, but their propagation would still be relatively poor. Indeed, static testing of the ShuRoo mounted on a vehicle parked on bitumen showed that the signal was undetectable beyond 50 m (Bender 2001), considerably less than 'approximately 400 metres ahead' claimed by the manufacturer (ShuRoo 2021). More tellingly, dynamic testing of the device fitted to a sedan, SUV, bus and truck showed that no components of the signal were detectable above the noise produced by these vehicles moving at 80 km/h (Bender 2001). These tests indicate that the ShuRoo is incapable of 'alerting kangaroos to your presence up to 400 metres away', and therefore cannot give kangaroos 'plenty of time to get out of your way' as claimed (ShuRoo 2021).

Even if the challenges of propagating an acoustic signal could be overcome, an effective acoustic deterrent must also produce a signal that can be detected by the target species. ShuRoo claims that the device 'creates a unique pattern of high-frequency sound that is silent to humans but creates an extremely loud police siren type of alert to kangaroos' (ShuRoo 2021). There are few published studies on the hearing of kangaroos. In one study of eastern grey kangaroos, the pinnae generated most acoustic gain (30 dB) at low frequencies (1.7–3.5 kHz), with lesser peaks at 16 and 18 kHz (Guppy 1985). Measurements of auditory brainstem response in tammar wallabies (*N. eugenii*) showed highest sensitivity to frequencies between 4 and 11 kHz and reduced sensitivity above 20 kHz (Cone-Wesson *et al.* 1997; Withington *et al.* 1995). Contrary to the manufacturer's claim, these studies show that kangaroo hearing is most sensitive to frequencies in the audible range for humans (Masterton *et al.* 1969), although kangaroos would probably be able to detect the ShuRoo signal if it were loud enough.

If detectable at a suitable distance, an effective acoustic deterrent must then elicit an appropriate behavioural response (Benten *et al*. 2019, D'Angelo and van der Ree 2015). However, there is no evidence that macropods respond to high-frequency sound in any appropriate way, such as moving away from the sound source. The ShuRoo did not change the vigilance or flight responses of captive eastern grey and red kangaroos when the device was turned on or off (Bender 2001). In controlled trials of the Roo-Guard, which was also marketed by ShuRoo, captive tammar wallabies (*N. eugenii*) were not deterred from using a feeder (Muirhead *et al*. 2006), and free-ranging eastern grey kangaroos were not deterred from foraging on pasture (Bender 2003). Similarly, the Hobi 'ultrasonic animal alert' whistle did not change Tasmanian macropod movements across, along or away from roads (Magnus *et al*. 2004).

The responsibility for avoiding collisions with wildlife lies largely with drivers, who have the capacity to change their behaviour in response to wildlife on the road (Seiler and Olsson 2017). The most important factor affecting driving speed is road surface (Gharraie and Sacchi 2020), but drivers also respond to the size of wildlife species on the roadway, being more likely to stop, slow or swerve when the animal is larger and potentially damaging to the vehicle (Kioko *et al*. 2015). Installing a deterrent, like the ShuRoo is consistent with protection motivation theory (McLeod *et al.* 2015): this response represents a coping action taken by drivers who seek to reduce the risk of a collision, which may evoke feelings of vulnerability and harm. Such a strategy may result in adaptive or maladaptive responses, depending on the alignment between the assessment of the threat and the driver's ability to cope with the situation. If drivers believe the ShuRoo manufacturer's claims that the device offers protection 400 m ahead and 50 m either side of the vehicle (ShuRoo 2021), and do not modify their driving behaviour to match the context, then the ShuRoo as a coping strategy is maladaptive. Furthermore, the perception of being protected by the ShuRoo could produce a rebound effect (Font Vivanco *et al.* 2018) if drivers then become less cautious. Although not statistically significant, the trend in our data was consistent with this effect (Table 2).

Conclusion

Our study is the only systematic evaluation of the ShuRoo in a field setting. We documented the frequency of collisions with macropods for a large sample of vehicles driven at all times of year over substantial distances. Based on drivers' reports of collisions, we conclude that the ShuRoo is ineffective, at best, in reducing the rate of collisions between vehicles and macropods. Previous research has demonstrated that the device does not meet the manufacturer's claims: the signal is inaudible above vehicle noise, target species are not sensitive to the signal, and the signal does not alter their behaviour. We therefore cannot recommend the use of this device to reduce the risk of collisions with macropods.

We do not envisage a simple solution to the problem of collisions with macropods. As Lunney (2013) pointed out, the engineering, ecological and animal welfare aspects of collisions do not fully encompass the breadth of the wildlife roadkill problem and are not sufficient to produce effective change. Seiler and Bhardwaj (2020) argue that we can achieve safe and sustainable road spaces for humans and wildlife if we face the numerous challenges from the outset. Their approach demands interdisciplinary cooperation, development of common standards and rules, and integration of mitigation strategies throughout every stage of road and railway design (Seiler and Bhardwaj 2020). Retro-fitting a single device like the ShuRoo is not consistent with this approach and is destined to fail.

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