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Response

Virtual fence devices – a promising innovation: a response to Coulson and Bender (2019)

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Abstract. Coulson and Bender (2019) have provided a critique to our paper 'Roadkill mitigation: trialing virtual fence devices on the west coast of Tasmania' (Fox *et al*. 2019). Here, we clarify some ambiguous points that have confused Coulson and Bender and refute other claims. Although we presented results from a single study and a trial, we stand by our claim that these devices hold great promise and are worthy of further research.

Additional keywords: management strategy, roadkill mitigation.

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Introduction

Mitigating wildlife roadkill is an issue discussed in the mainstream media as much as peer-reviewed articles due to the emotion that the death of wildlife on our roads often invokes (Anon. 2018). This 'conversation' is perhaps nowhere more intense or consistent than in Tasmania, where wildlife roadkill is a constant scourge (Hobday and Minstrell 2008). Trialing a new mitigation method in Tasmania, therefore, seems prudent. Coulson and Bender (2019) have provided a critique of our paper 'Roadkill mitigation: trialing virtual fence devices on the west coast of Tasmania' (Fox *et al*. 2019).

Our research paper held the top spot for downloads for weeks following its initial release, indicating that roadkill mitigation is a subject in which many hold an interest. The principal concerns that Coulson and Bender (2019) have raised can be summarised as: the conceptual basis is unsound, the study design and data analysis are deficient, and the conclusions lack sufficient caution. We will cover each of these in turn.

The 'virtual fence' concept

Coulson and Bender (2019) mention the lack of peer-reviewed articles on the virtual fence technology before our study, and, indeed, this is the case. To determine whether there were any reports on the efficacy of the virtual fence devices that we had missed, we contacted the manufacturer and were provided with an official transcript from the Austrian Federal Government from a press conference where they outlined the results of studies on the efficacy of the virtual fence devices. In the first study conducted on this technology, 30 previously identified 'hotspots' were monitored between 2003 and 2007 with a 93% reduction in roadkill, while the second survey compared roadkill over 105 km of road with installed devices, with an overall reduction of 77%. The transcript also mentions three different roads that were monitored during 2010 and 2011 with a reduction of roadkill of 85–100% (https://www.land-oberoesterreich.gv.at/Mediendateien/LK/PK_LH-Stv.Hiesl_29.10_Internet.pdf, Austrian Federal Government, October 2012). However, no details on study design or analysis were provided.

Coulson and Bender (2019) have provided a thorough description of previous research on the use of light and sound stimuli as roadkill mitigation. However, their examples of stimuli that have been ineffective are not comparable to those found in the virtual fence devices. That is, they compare static single-coloured wildlife warning *reflectors* (Benten *et al*. 2018*a*, 2018*b*), with active flashing multicoloured lights on the virtual fence devices, and whistles attached to vehicles that can't be heard over the sound of the vehicle (Magnus *et al*. 2004; D'Angelo and van der Ree 2015), with warning alarms on the virtual fence devices that are on the side of the road close to the animal they are trying to warn. Nevertheless, they summarise the capacity of marsupials to detect the light and sound stimuli provided by the virtual fence devices and conclude that '. . . the royal blue light produced by the 'virtual fence' is a reasonable match to the peak sensitivity of short wavelength cones in both dichromatic and trichromatic marsupials, suggesting that all the Tasmanian species would be able to detect this light . . .', and '. . . behavioural and electrophysiological studies of the auditory system of Australian marsupial taxa suggest that the Tasmanian species would be sensitive to sound produced at both settings . . .'. In their conclusion of the 'virtual fence' concept, Coulson and Bender (2019) highlight a single study (Langbein *et al*. 2011) that discusses the use of products that use a combination of light and sound but again compare the virtual fence device (with flashing lights) with models that have static reflectors, although they do state 'The underlying assumption is that mixing signal modalities will increase the response rate or reduce the likelihood of habituation by the target species'. In summary, the virtual fence devices appear to have light and sound stimuli that fall within the receptive capabilities of Australian marsupial species, and having flashing light and sound acting together may be the crucial element that provide the significant results observed in our trial.

Study design and analysis

Coulson and Bender (2019) maintain that the design and analysis of our study are flawed. Their first point is that the data were collected at a low resolution of 1 km. This is not correct. They have unfortunately taken the text written literally: 'The distance (in kilometres, from the cattle grid) was recorded . . .' (Fox *et al.* 2019), where, in fact, all roadkill was recorded to 0.1 of a kilometre, as all odometers are able to record.

Second, Coulson and Bender (2019) point out that the preinstallation survey was conducted for only a 4-month period. We cannot refute this. However, as is clear in all of the roadkill data collected in this area, spring and summer (when the preinstallation survey occurred) are considered to be the time of year when most roadkill occurs, hence providing the greatest sample size. Coulson and Bender (2019) also point out that seasonal patterns have been found in roadkill in Tasmania in previous studies (Hobday and Minstrell 2008), and, indeed, the highest rate of roadkill was also found in summer in this study. They also admit that the two most commonly killed species in our study did not show a seasonal pattern.

Coulson and Bender (2019) next discuss the validity of our use of a t-test to analyse the uniformity of roadkill along the 13 km of road monitored. We refute this and provide several other studies on roadkill that have used similar statistical approaches to measure comparable aspects to our study (Quintero-Angel *et al.* 2012; Collinson *et al.* 2017; Carvalho *et al.* 2018; Jeganathan *et al.* 2018; Vidal-Vallés *et al.* 2018). Additionally, Coulson and Bender (2019) argue that a key assumption of a t-test was violated in our study, namely that observations were not independent of each other, i.e. that once an animal has been killed it is not available to be killed again. While this is indeed true, the assumption of the t-test is that the two compared sites across each month (i.e. the fenced and unfenced regions) are independent. To show that this assumption of independence between months was not violated, we carried out further analysis, fitting a Generalised Linear Model for data on Bennett's wallaby, pademelon and all data combined. The response variable was the roadkill rate in each section of road, and the explanatory variables were the treatment type (i.e. whether the segment of road was fenced or unfenced), month and year effects. The model selection based on Akaike Information Criteria selected the full model (treatment, month and year effect) as the 'best' model in all cases tested. In all cases the coefficient of treatment type was significant (Bennetts wallaby: coefficient for Treatment is significant at $\alpha = 0.1$ (if outside the fence, 0.096, s.e. = 0.051, $P = 0.064$); pademelon: coefficient for Treatment is significant at $\alpha = 0.05$ (if outside the fence, 0.281, s.e. = 0.077, $P = 0.0005$); all data: coefficient for Treatment is significant at $\alpha = 0.05$ (if outside the fence, 0.485, s.e. = 0.127, $P = 0.0003$)). There was no evidence of serial autocorrelation in any of the residuals, i.e. the assumption of independence is met.

Habituation

Coulson and Bender (2019) point out that our study did not give any consideration to habituation. While they are correct, we believe that habituation can only be addressed via GPS collaring to assess animal movement patterns and behavioural changes before, and for many years after, virtual fence installation, which is clearly outside the scope of this study. However, we have three years of data in our study showing a marked difference in roadkill between stretches of road with virtual fencing and those stretches without. If habituation were to occur, we believe that three years of reduced roadkill before habituation set in is better than nothing at all. Another advantage to these compact devices is that they are easily removed and erected elsewhere if there is evidence of their no longer being effective.

Conclusion

Finally, Coulson and Bender take exception to our belief that these devices 'show great potential'. Clearly, this is a single study and a trial, which we have even highlighted in the title of our paper, and more research on the efficacy of these devices is needed on other roads over extended periods to understand just how great this potential could be.

Conflicts of interest

The authors declare no conflict of interest.

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