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*Improving animal welfare standards while reducing disease exposure risk during euthanasia of trapped brushtail possums (*Trichosurus vulpecula*)*

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Abstract

*In New Zealand there is a long history of research studies working with wild free-living brushtail possums (*Trichosurus vulpecula*) where euthanasia of large numbers of animals is frequently required. The most commonly used method for euthanising trapped possums is by blunt-force trauma. If possums being euthanised are potentially infected with bovine tuberculosis (TB), however, the blunt-force trauma method is associated with risks of researcher exposure to TB infection (eg risk of being scratched, bitten or blood-splattered). Here, we trial the use of a close-range shot to the head with a high-velocity air rifle as an alternative method for the euthanasia of cage-trapped possums. Our trial revealed that the air rifle method reduced the potential disease exposure risks to researchers by minimising blood-spatter area, and by completely avoiding the likelihood of both accidents due to animal handling and animal escapes. While both methods induced immediate unconsciousness leading to death, the air rifle method was quicker (ie shorter conscious handling and total time) and arguably had better animal welfare performance by significantly reducing the time to unconsciousness. Thus, we conclude that the air rifle method is suitably humane for possum euthanasia and should be considered when dealing with potentially TB-infected cage-trapped possums.*

Keywords: *air rifle, animal welfare, blunt-force trauma, shooting, tuberculosis, wildlife capture*

Introduction

In New Zealand the introduced brushtail possum (*Trichosurus vulpecula*) is a major pest impacting on a range of conservation values and acting as the main wildlife reservoir of bovine tuberculosis (TB; Cooke *et al* 1995; Nugent *et al* 2015). There is, thus, a long history of research studies working with wild free-living possums (eg Cowan 2001; Tompkins *et al* 2009; Gormley *et al* 2012; Nugent *et al* 2015) where euthanasia of large numbers of animals is frequently required to, for example, assess diet (eg Glen *et al* 2012; Sweetapple *et al* 2013), enumerate parasites (Cowan *et al* 2002, 2006), or detect sub-clinical cases of TB (eg Whitford *et al* 2014: Nugent *et al* 2015).

Animal welfare standards for trapping and/or killing animals should be a priority, and should minimise the pain and disruption for the species being handled (Iossa *et al* 2007). Regardless of the status of the species (eg as a recognised pest species such as the possum in New Zealand), they must be killed using the most humane method possible (Littin *et al* 2004). In New Zealand, the most commonly used method for euthanising possums trapped alive is by blunt-force-trauma (NPCA 2009). This consists of removing the animal from the trap by its tail, placing its head over a solid object (eg a rock or a hard tree root), and delivering a hard 'stunning' blow to the back of the head (usually using a hammer), followed by additional blows until the skull is crushed. The use of the blunt-force-trauma method is less aesthetically acceptable for many species than alternative euthanasia methods (eg inhaled anaesthetics like carbon monoxide or halothane, or injectable anaesthetics like pentobarbital combinations; AVMA 2013); however, when properly performed, it can be appropriate for some species (eg lambs: Finnie *et al* 2000; kangaroo joeys: McLeod & Sharp 2014). Through decades of experience and refinement in New Zealand, it is considered an effective and humane method for euthanising possums (NPCA 2009). If possums being euthanised are potentially infected with TB, however, the blunt-force-trauma method is associated with risks of researcher exposure to TB infection. For example, the necessity of removing individuals from cages prior to euthanasia puts the handler at risk of being scratched and bitten (eg Goldstein & Abrahamian 2015). In addition, a blow to the head can cause blood-splash which could be a potential source of TB contamination if it comes into contact with the skin (Twomey *et al* 2010).

Figure 1

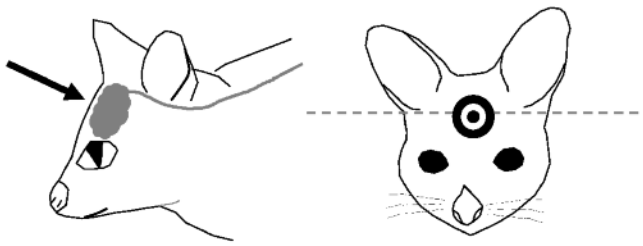

Illustration showing brain location in the brush-tailed possum (*Trichosurus vulpecula*), and the air rifle target for euthanasia used here. The air rifle pellet should enter the skull at the centre of the possums' head, slightly below a line drawn midway between the ears, to be centred on the brain.

Here, we trial the use of a close-range shot to the head with a high-velocity air rifle as an alternative method for the euthanasia of cage-trapped possums. We hypothesise that by both removing the need to handle individuals, and reducing the extent of blood-spatter produced compared to blunt-force trauma, this method will reduce potential disease exposure risks to researchers while maintaining humane animal ethics standards. Past assessments of air rifles (with muzzle velocities of less than 400 feet s^{-1}) for this purpose, concluded that they were not suitable for euthanising possums, as they are less powerful than conventional firearms and thus cause insufficient penetration of the skull and damage to the brain to reliably kill possums with a single shot (NPCA 2009). However, modern air rifles have muzzle velocities up to 1,200 feet s^{-1}. Based on reports from other studies of small animals (Whiting *et al* 2011); we hypothesised that a close-range headshot with these higher velocities is sufficiently powerful to reliably and safely kill a medium-sized mammal such as the possum.

Materials and methods

Study site and possum trapping

We took advantage of an ongoing research project investigating TB transmission among wild free-living possums (Whitford *et al* 2014), for which purpose the individuals studied here already required euthanasia. The study population inhabits a 1,200 ha research area in the Orongorongo Valley (lower North Island, New Zealand [lat –41°21'S; long –174°58'E]. The study site is characterised by mixed, native broadleaf-conifer forest interspersed with small areas of scrub, which has supported possum densities of about nine per hectare for the past 40–50 years (Efford 2000).

Possums were caught in Grieve wire cage traps (60 × 26 × 28 cm; length × width × height), with a spring-assisted folding door triggered by a pendulum hook (Montague & Warburton 2000), in four nights consecutive trapping in June 2014. Traps were set on the ground, baited each morning with apple sprinkled with powdered sugar and flour with anise oil applied as a lure, and checked every day.

Experimental procedure

To compare the extent of blood-spatter produced by possum euthanasia by the high-velocity air rifle with the established blunt-force-trauma method, while ensuring that welfare standards of performance were not compromised by this new approach, several measures were compared during the termination of two groups of 30 adult possums (15 male and 15 female), one group for each treatment. For the air rifle method, possums received a single shot from a Gamo® Big Cat 1000 (4.5 mm calibre, minimum velocity 1,000 feet s^{-1}; Barcelona, Spain) through the bars of the trap at no greater than 5 cm distance from the possum, aimed at the centre of the animals' forehead to ensure severe brain damage. (Figure 1; see Longair *et al* 1991). Super-heavy pointed pellets were used for high impact and maximum expansion (4.5-mm calibre with 0.75 g weight each; Stoeger Airguns® X-Magnum, Accokeek, USA).

The air rifle used was a single-shot model and pellets were only chambered directly before dispatching possums in order to reduce the risk of accidental discharge. Any rocks located underneath the cage were removed before setting up the trap in order to reduce the risk of ricochet. Although we predicted that animals would be immediately unconsciousness as a result of this method, to minimise any unnecessary suffering we planned to: (i) give them a second shot within 10 s; and (ii) euthanise them by blunt-force trauma, if they failed to lose consciousness. The blunt-force-trauma method followed the protocol outlined in the *Introduction* (NPCA 2009). For both methods, the largest diameter of any blood-spatter area produced was recorded using a tape measure (to the nearest 5 cm for any spatter over 10 cm), in addition to any scratches received by handling staff, and any situation where there was a likelihood of the handled possum escaping. All animal manipulation for this research was undertaken with approval of the Landcare Research Animal Ethics Committee (approval no 12/02/01).

We adapted welfare standards of performance from Iossa *et al* (2007). For each animal we recorded: conscious handling time (CHT: ie, from approaching within 1 m of the cage to unconsciousness); time to unconsciousness (TU: ie from shot/blunt force to loss of blink response); time to death (TD: ie, from shot/blunt force to breath cessation); total time (TT: ie, from approaching within 1 m of the cage to possum death); and the number of hit/shots used to kill each animal. During subsequent necropsy for TB, animals were also examined to assess air rifle pellet penetration and determine pellet location (ie still present in the cranium, or having gone clean through). Comparisons of all measures between the two methods were made by two-tailed *t*-test using the package 'stats' in programme R version 3.1.1 (R Core Team 2013). All time measures were log-transformed to satisfy assumptions of normality and homogeneity of variances.

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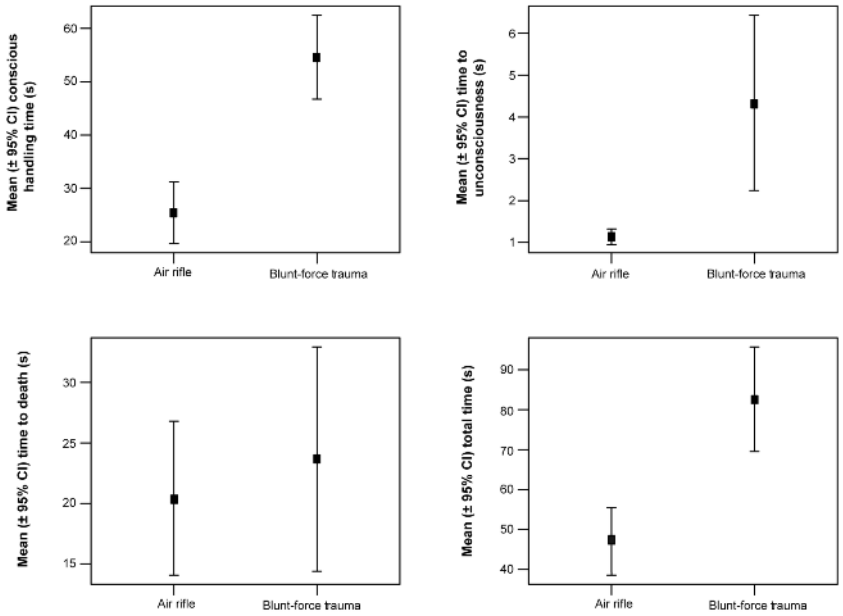
Figure 2

Mean (± 95)% confidence intervals (CI) of conscious handling time (CHT), time to unconsciousness (TU), time to death (TD) and total time (TT) (s), of possums euthanised using air rifle shot (n = 30) and blunt-force trauma (n = 30).



Results

For the thirty possums euthanised by the air rifle method, no blood-splatter was recorded but rather blood flowed linearly from the entrance wound created by the pellet resulting in a small puddle on the ground. In contrast, blood-spatter areas ranging in diameter from 5–100 cm (average diameter 17.2 cm) were produced from the thirty possums euthanised by blunt-force trauma. Although the mean linear distance travelled by blood contamination from the air rifle method was slightly larger than the mean diameter of blood-spatter area from the blunt-force-trauma method, the area coverage (and variance of spread) was much greater for the latter. Two possums escaped, and one minor handler injury (a small scratch) occurred, both during euthanasia via blunt-force trauma. In contrast, no such issues occurred with the air rifle method.

For the welfare standards of performance, both conscious handling time (CHT) and time to unconsciousness (TU) were significantly shorter with the air rifle than with the blunt-force-trauma method (t-test = 6.11; $P < 0.00001$, and t-test = 3.11; $P = 0.0041$, respectively; Figure 2). No differences were found in the time to death (TD) produced by the two methods (t-test = 1.1; $P = 0.27$; Figure 2). Seven possums out of 30 were shot twice to ensure unconsciousness; however, possums required significantly less shots than blunt-force trauma possums required hits (means [± 95]% CI of 1.23 [± 0.16] and 3.1 [± 0.54], respectively; t-test = 6.7; $P < 0.00001$). No back-up blunt-force trauma was needed for any possum euthanised by air rifle. Finally, the total time (TT) it took to euthanise a possum was significantly shorter with the air rifle method than with blunt-force trauma (t-test = 4.7; $P < 0.0001$; Figure 2). Detailed data were not collected on areas of brain destroyed, but necroscopy observations to determine the fate of the pellet suggested that trauma to the brain was severe in all cases; 90% of pellets were found inside the skull cavity with exit wounds noted for the other 10%.

Discussion

This is the first published study to assess the effectiveness of shot by high-velocity air rifle versus blunt-force trauma for the humane killing of brushtail possums in the field. Our trial revealed that the high-velocity air rifle method to euthanise cage-trapped possums reduced the potential disease exposure risks to researchers by minimising blood-spatter area, and by completely avoiding the likelihood of accidents due to both animal handling and animal escapes. This is important when dealing with a disease that can be transmitted to an operator through a handling accident (Cooke *et al* 2002; Twomey *et al* 2010). While both methods induced immediate unconsciousness leading to death, the air rifle method was quicker (ie, shorter conscious handling [CHT] and total time [TT]) and had better welfare performance by significantly reducing the time to unconsciousness. In addition, restraint and removal in cage traps causes stress to possums (Warburton *et al* 1999); the air rifle method would therefore likely decrease possum stress levels prior to euthanasia since there is no need to handle the animal to remove it from the cage.

Both methods of possum euthanasia trialled here cost next to nothing to employ (after capital investment of approximately NZ$20 for a hammer versus NZ$320 for an air rifle with 500 pellets). Blunt-force trauma has some advantages over the use of air rifles; a hammer is easier to carry in the field and its use leaves no environmental

residue. However, the efficiency of the hammer method depends on the strength and skill of the operator for consistency of application (Erasmus *et al* 2010), and replication without incident may be difficult to apply humanely to large numbers of animals (AVMA 2013). In contrast, air rifles can be more inconvenient to carry in the field and, although licencing is not required for their use, appropriate operator training is advised. The main non-animal welfare concern of this method is the safety risks to personnel from pellet ricochet. In the current trial, our results showed that air rifle pellets went through the skull of the animal on only 1 in 10 occasions (and the risk of injury via ricochet would be further reduced by the impact with the skull greatly reducing the speed of the pellet). We thus posit that the findings of this study strongly support the use of high-velocity air rifles as a suitable and humane approach to the euthanasia of small mammals such as possums when caught in cage traps. It minimises distress and improves animal welfare standards of euthanasia while significantly reducing the risk of operator exposure to disease. However, it should be noted that the use of cages to live-trap possums in New Zealand is non-standard for control of the species; most live-trapping conducted makes use of leg-hold traps for which the air rifle method would not be suitable due to movement of the trapped possums being too great.

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References

AVMA 2013 *Guidelines for the Euthanasia of Animals: 2013 Edition*. American Veterinary Medical Association: Illinois, USA. www.avma.org/KB/Policies/Documents/euthanasia.pdf

Cooke MM, Gear AJ, Naidoo A and Collins DM 2002 Accidental *Mycobacterium bovis* infection in a veterinarian. *New Zealand Veterinary Journal 50*: 36-38. http://dx.doi.org/10.1080/ 00480169.2002.36248

Cooke MM, Jackson R, Coleman JD and Alley MR 1995 Naturally occurring tuberculosis caused by *Mycobacterium bovis* in brushtail possums (*Trichosurus vulpecula*) II. Pathology. *New Zealand Veterinary Journal 43*: 315-321. http://dx.doi.org/10.1080/ 00480169./1995.35912

Cowan PE 2001 Advances in New Zealand mammalogy 1990–2000: Brushtail possum. *Journal of The Royal Society of New Zealand 31*: 15-29. http://dx.doi.org/10.1080/03014223.2001.9517636

Cowan PE, Heath DD and Stankiewicz M 2002 Local variation in endoparasite infection of brushtail possums, *Trichosurus vulpecula*, along a forest margin transect, lower North Island, New Zealand. *New Zealand Journal of Zoology 29*: 171-176. http://dx.doi.org/10.1080/03014223.2002.9518300

Cowan PE, Ralston MJ, Heath DD and Grant WN 2006 Infection of naïve, free-living brushtail possums (*Trichosurus vulpecula*) with the nematode parasite *Parastrongyloides trichosuri* and its subsequent spread. *International Journal for Parasitology 36*: 287-293. http://dx.doi.org/10.1016/j.ijpara.2005.11.004

Efford MG 2000 Possum density, population structure, and dynamics. In: Montague TL (ed) *The Brushtail Possum: Biology, Impact and Management of an Introduced Marsupial* pp 47-61. Manaaki Whenua Press: Lincoln, New Zealand

Erasmus MA, Lawlis P, Duncan IJ and Windowski TM 2010 Using time to insensibility and estimated time of death to evaluate a non-penetrating captive bolt, cervical dislocation, and blunt trauma for on-farm killing of turkeys. *Poultry Science 89*: 1345-1354. http://dx.doi.org/10.3382/ps.2009-00445

Finnie JW, Blumbergs PC, Manavis J, Summersides GE and Davies RA 2000 Evaluation of brain damage resulting from penetrating and non-penetrating captive bolt stunning using lambs. *Australian Veterinary Journal 78*: 775-778. http://dx.doi.org/10.1111 /j.1751-0813.2000.tb10451.x

Glen AS, Byrom A, Pech PR, Cruz J, Schwab A, Sweetapple PJ, Yockney I, Nugent G, Coleman M and Whitford J 2012 Ecology of brushtail possums in a New Zealand dryland ecosystem. *New Zealand Journal of Ecology 36*: 29-37

Goldstein EJ and Abrahamian FM 2015 Animal bites and zoonoses: from A to Z: alligators to zebras. In: Sing A (ed) *Zoonoses-Infections Affecting Humans and Animals* pp 659-679. Springer: The Netherlands. http://dx.doi.org/10.1007/978-94-017-9457-2_26

Gormley AM, Holland EP, Pech RP, Thomson C and Reddiex B 2012 Impacts of an invasive herbivore on indigenous forests. *Journal of Applied Ecology 49*: 1296-1305. http://dx.doi.org /10.1111/j.1365-2664.2012.02219.x

Iossa G, Soulsbury CD and Harris S 2007 Mammal trapping: a review of animal welfare standards of killing and restraining traps. *Animal Welfare 16*: 335-352

Littin KE, Mellor DJ, Warburton B and Eason CT 2004 Animal welfare and ethical issues relevant to the humane control of vertebrate pests. *New Zealand Veterinary Journal 52*: 1-10. http://dx.doi.org/10.1080/00480169.2004.36384

Longair J, Finley GG, Laniel M, MacKay C, Mould K, Olfert ED, Rowsell H and Preston A 1991 Guidelines for euthanasia of domestic animals by firearms. *Canadian Journal of Veterinary 32*: 724-726

McLeod SR and Sharp TM 2014 *Improving the humaneness of commercial kangaroo harvesting*. Rural Industries Research and Development Corporation: Barton, Australia

Montague T and Warburton B 2000 Non-toxic techniques for possum control. In: Montague TL (ed) *The Brushtail Possum: Biology, Impact and Management of an Introduced Marsupial* pp 164-174. Manaaki Whenua Press: Lincoln, New Zealand

National Possum Control Agencies 2009 *Leghold traps. A guideline for capturing possums, ferrets and feral cats using leghold traps*. NPCA: Wellington, New Zealand. http://www.npca.org.nz/images/stories/NPCA/PDF/a4.1%20leg-trap%202009-05.pdf

Nugent G, Buddle BM and Knowles G 2015 Epidemiology and control of *Mycobacterium bovis* infection in brushtail possums (*Trichosurus vulpecula*), the primary wildlife host of bovine tuberculosis in New Zealand. *New Zealand Veterinary Journal 3*: 1-14

R Core Team 2013 *R: A language and environment for statistical computing*. R Foundation for Statistical Computing: Vienna, Austria. http://www.R-project.org/

https://doi.org/10.7120/09627286.24.3.235 Published online by Cambridge University Press

Sweetapple PJ, Ruscoe WA and Nugent G 2013 Dietary changes in response to population reduction in the possum *Trichosurus vulpecula* in New Zealand. *Wildlife Research*. *40*: 561-569. http://dx.doi.org/10.1071/WR13118

Tompkins DM, Ramsey DSL, Cross ML, Aldwell FE, Lisle GW and Buddle BM 2009 Oral vaccination reduces the incidence of tuberculosis in free-living brushtail possums. *Proceedings of the Royal Society Series B276*: 2987-2995. http://dx.doi.org/ 10.1098/rspb.2009.0414

Twomey DF, Higgins RJ, Worth DR, Okker M, Gover K, Nabb EJ and Speirs G 2010 Cutaneous TB caused by *Mycobacterium bovis* in a veterinary surgeon following exposure to a tuberculous alpaca (*Vicugna pacos*). *Veterinary Record 166*: 175-177. http://dx.doi.org/10.1136/vr.b4780

Warburton B, Gregory NG and Bunce M 1999 Stress response of Australian brushtail possums captured in foothold and cage traps. In: Proulx G (ed) *Mammal Trapping* pp 53-66. Alpha Wildlife Research & Management Ltd: Alberta, Canada

Whitford J, Rouco C, Tompkins D and Nugent G 2014 First direct estimate of the detection probability of bovine tuberculosis in possums by possum-transmission. *European Journal of Wildlife Research 60*: 827-830. http://dx.doi.org /10.1007/s10344-014-0834-z

Whiting T, Steele GS, Wamnes S and Green C 2011 Evaluation of methods of rapid mass killing of segregated early weaned piglets. *Canadian Veterinary Journal 52*: 753-758