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EFFECT OF JAW SHAPE IN KILL-TRAPS ON TIME TO LOSS OF PALPEBRAL REFLEXES IN BRUSHTAIL POSSUMS

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ABSTRACT: The effect of three configurations of the jaw of kill-traps on time to loss of palpebral reflex of brushtail possums (*Trichosurus vulpecula*) was assessed. Traps were Standard, with an offset rotating jaw closing past a pear-shaped constriction, Offset, with a rotating jaw closing past a straight edge, and Opposing, with a rotating jaw closing directly onto a static bar. Possums captured in the Standard and Offset traps had significantly lower times to loss of palpebral reflexes (42 and 50 sec respectively) than those captured in Opposing traps (122 sec). Both the Standard and Offset traps achieved total occlusion of both carotid arteries more frequently than the Opposing trap. Thus the killing effectiveness of kill traps designed for capturing possums can be improved by offsetting the jaws without the need to increase the power of the trap. Therefore, for some target species, such modifications might satisfy the demands of animal welfare proponents for traps that kill rapidly, without compromising trapper safety.

Key words: Animal welfare, brushtail possum, carotid occlusion, kill traps, standards, trapping, *Trichosurus vulpecula.*

INTRODUCTION

Brushtail possums (*Trichosurus vulpecula*) are a widespread pest in New Zealand and are extensively trapped, primarily with leg-hold traps, to reduce their impact on the environment, and to a lesser extent for their fur. The use of leg-hold traps, particularly the serrated-jaw "Lanes-Ace" gin trap (Lanes Hardware Ltd, Galdesville, NSW, Australia) has received persistent opposition from animal welfare proponents, and research has been carried out to determine whether this leg-hold trap could be replaced by potentially less injurious traps, such as the Victor No. 1, and the Victor Soft Catch No. 1 and 1½ traps (Woodstream Corp., Lititz, Pennsylvania, USA), (Warburton, 1992). Although significant reductions in the extent and severity of injuries can be obtained by using the smaller Victor leg-hold traps, there is a general preference among welfare proponents for kill-traps which do not require the captured animal to stay alive until the trapper returns. Unfortunately, not all kill-traps kill the captured target animal quickly (Warburton and Orchard, 1996) and most would not pass the requirement of the draft New Zealand National Trap Standard (Warburton and Hall, 1995), 3 min to loss of palpebral reflex.

Internationally, there has also been considerable effort to develop effective kill-traps (Proulx and Barrett, 1991, 1993), and improve trap use through the development of draft international standards (Jotham and Phillips, 1994). Kill-traps are evaluated on the basis of the time it takes for the trap to render the animal insensible to pain, most often measured by the loss of palpebral (blinking) reflex (Rowsell et al., 1981; ISO, 1999). During the development of international standards, a 3 min time to loss of palpebral reflex was considered achievable by at least some kill-traps in current use (Jotham and Phillips, 1994), however, animal welfare proponents argued that this time should be reduced to 30 sec and preferably zero. Although such a rapid death might be technically achievable if factors such as practicality and user safety are ignored, these factors cannot be dismissed and therefore impose real constraints on the size and power of traps.

Because of the conflict between the size and user-safety constraints and the need to shorten the time to insensibility, trials were carried out to determine whether trap-jaw configuration was an important component of killing effectiveness. That is, for any given impact momentum and/or clamping force (Newcombe, 1981) can the time to loss of brain stem reflexes be minimized? Such an approach could enable kill traps to be developed that meet animal welfare demands without compromising the safety of the trapper.

MATERIAL AND METHODS

Timms possum kill traps (K. B. L. Rotational Moulders, Palmerston North, New Zealand) were selected as the killing system for assessing the effect of jaw configuration on time to loss of palpebral reflexes because the trap jaws could be modified without significantly altering the trap's operation. There were three treatments tested. First, an unmodified Timms trap (K. B. L. Rotational Moulders) (Standard trap) had a "pear-shaped" exterior hole with a striking bar that rotated upwards to lock the neck of the possum in the narrow part of the hole. The striking bar was offset into the trap by 5 mm and could completely pass the top of the exterior hole (Fig. 1A). Second was a Timms trap (Offset) modified by extending the top of the exterior hole out to the width of the broadest part of the hole leaving a straight top edge (Fig. 1B). Finally, a Timms trap (Opposing) with the same modification of the exterior hole as the Offset trap, but with the addition of a static striking bar that the rotating bar could close onto (Fig. 1C). Using the basic Timms trap for all treatments allowed the clamping force and impact momentum to be held constant while testing jaw modifications. All traps had a window cut in the back of the trap to provide access to the possum's eye for checking the palpebral reflex.

Twelve possums ranging in weight from 1.6 kg to 3.6 kg were tested in each trap type. About 4 to 5 hr prior to testing, each possum was subcutaneously injected with 500IU of heparin to prevent blood coagulation. To place the possums in the trap they were constrained in a length of PVC pipe and the head positioned in the trap to allow for a ventral neck strike and ensure that each possum entered the trap in the identical position. Once the trap was sprung the possum was allowed to freely resist. The palpebral reflex was tested every 5 to 10

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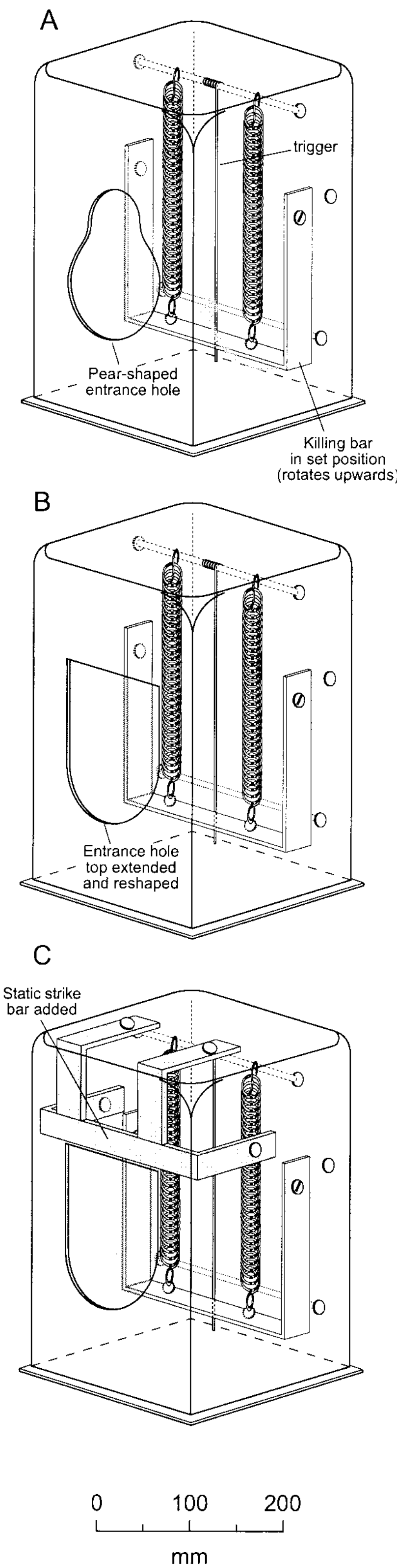

FIGURE 1. The Standard Timms kill trap (A) with the outer hole modified (B) and with the outer hole modified and a static opposing striking bar added (C).

TABLE 1. Mean possum body weight (kg) and time (sec) to loss of palpebral reflexes of possums captured in three types of kill traps.

Trap type	*n*	Mean possum body weight	Mean time ± SE to loss of palpebral reflex
Standard	12	2.47	42.25 ± 5.4
Offset	12	2.44	49.83 ± 5.6
Opposing	12	2.70	121.83 ± 16.2[a]x

[a] Significantly different than Standard and Offset traps at $\alpha = 0.05$ (Bonferroni adjusted pairwise comparisons). When possums were euthanased at 3 min, this was taken as the time to loss of palpebral reflex.

sec by touching the edge of the eye with a blunt rod until the blinking response stopped or until 3 min had lapsed. If the blinking response had not stopped by 3 min, the possum was euthanased with an intracardial injection of 200 mg/kg of sodium pentobarbital. For possums that had to be euthanased the time to loss of palpebral reflex was recorded as 3 min, resulting in a conservative mean time for loss of reflex.

Once the heart had stopped each possum was placed on its back, taking care not to disturb the position of the possum in the trap. The abdominal and thoracic cavity were then opened and a cannula placed in the aorta into which a water-based dye could be perfused. The neck, immediately anterior to the striking bar, was severed to expose the arterial pathways. A water-based dye was then perfused using a 50-ml syringe and any flow anterior to the striking bar noted. If little or no flow was noted, the striking bar was gradually raised while dye was still being perfused to ensure the arteries were open and not blocked with clotted blood. The degree of carotid occlusion on both sides of the neck was recorded as total, partial, or nil.

The effect of treatment on time to loss of palpebral reflex was tested by analysis of covariance (ANCOVA) using body weight as a covariate. The relationship between the extent of carotid occlusion and time to loss of palpebral reflex was also tested using ANOVA. Samples were tested for equal variance using an F_{max} test (Sokal and Rohlf, 1995). Times to loss of palpebral reflex were normalised using a log transformation. The frequencies of possums with different carotid status were tested using the Fisher's Exact Test (S-PLUS, MathSoft, Inc., Seattle, Washington, USA).

This project was carried out with the approval of the Landcare Research Animal Ethics Committee (Lincoln, New Zealand) and in accordance with the guidelines of the National Animal Ethics Committee of New Zealand (Wellington, New Zealand).

RESULTS

Effect of treatment on time to loss of palpebral reflex

There was no significant difference in the body weights of possums between treatments ($F = 0.566$; 2,33 df; $P = 0.573$) (Table 1). There was no covariate effect of body weight on the time to loss of palpebral reflex so body weight was removed from the analyses.

The time to loss of palpebral reflex varied from 15 sec to greater than 3 min with a significant treatment effect ($F = 18.32$; 2,33 df; $P < 0.001$). The Standard trap and the Offset trap had similar mean times to loss of palpebral reflexes, but the Opposing trap had significantly greater times (Table 1). Four possums captured in the Opposing trap were still conscious after 3 min and had to be euthanased. All possums captured in the Standard trap were killed, with a maximum time to loss of palpebral reflex of 77 sec, and six possums losing their reflexes within 35 sec. Similarly, only four possums captured in the Offset trap retained their palpebral reflexes for longer than 60 sec, with the maximum at 84 sec.

Extent of carotid occlusion status and time to loss of palpebral reflex

Carotid occlusion status ranged from total occlusion on both sides, which occurred most frequently in possums captured in the Standard trap, to both sides being open (Table 2). The frequency of the various carotid occlusions was different between trap types, with the Opposing trap having significantly less "both total" than the Standard and Offset traps (Fish-

TABLE 2. Frequency of occlusion status of carotid arteries of possums captured in three trap types.

Carotid occlusion status	Trap type		
	Standard	Offset	Opposing
Both total	11	6	1
One total, one open	0	0	4
One partial, one open	0	0	3
Both partial	1	0	1
One total, one partial	0	5	2
Both open	0	0	1

TABLE 3. Time (sec) to loss of palpebral reflex following kill trapping for each of six occlusion classes of carotid arteries.

Carotid occlusion status	n^a	Time ± SE to loss of palpebral reflex
Both total	18	44.7^b ± 4.6
One total, one open	4	110.2 ± 23.9
One total, one partial	7	55.1 ± 9.3
One partial, one open	3	193.3 ± 13.3
Both partial	2	70.5 ± 19.5
Both open	1	140.0

[a] Because of accidental release of the striking bar one possum was not able to be checked for carotid occlusion status.
[b] When possums were euthanized at 3 min, this was taken as the time to loss of palpebral reflex.

er's exact test, $P < 0.001$). The status of carotid occlusion also had a significant effect on the time to loss of palpebral reflex ($F = 9.795$; 5,29 df; $P < 0.001$) (Table 3).

DISCUSSION

The performance of the three jaw configurations tested in these trials shows that significant differences in time to loss of palpebral reflexes can occur even when clamping force and impact momentum are held constant. The clamping force of the basic Timms trap (ca. 55 N) was theoretically too low to achieve a rapid death based on clamping force and impact momentum threshold values reported for possums by Warburton and Hall (1995). However, the threshold values were derived using a trap simulator that had two straight bars opposing each other—the same configuration as that used in the Opposing Timms trap. Warburton and Hall (1995) suggested that jaw configuration could affect killing effectiveness. The results from this work show that, at least for brushtail possums, significant increases in killing efficiency can be achieved by having the jaws offset.

There was no indication that the "pear-shaped" external hole added any efficiencies, in terms of time to loss of sensibility, over and above the straight offset jaws. Initial tests with the straight jaw showed that the 55 N clamping force was inadequate to hold possums in the traps. To prevent possums pulling out of the modified traps, a locking mechanism was attached to prevent the striking bar being lowered once it had struck the possum. Although the Standard Timms trap does not have a locking mechanism, possums do not escape because the neck is held up in the narrow part of the "pear-shaped" external hole which, being narrower than the diameter of the possum's head, prevents it from escaping. Thus, although the "pear-shaped" external hole did not reduce time to loss of palpebral reflexes, it was important as a restraining mechanism while the animal was rendered insensible.

The degree of carotid occlusion achieved by an offset jaw configuration may depend on the muscle and circulatory anatomy of the captured animal. Possums have vertebral arteries that can supply blood to the hind brain if the carotids are occluded (Nutman et al., 1998). However, it would appear this route is insufficient by itself to maintain consciousness. Only one (8%) of the possums captured in the Opposing trap had total occlusion of both carotid arteries compared to 11 (92%) possums captured in the Standard trap. It is likely that dorsoflexion of the neck would cause the common carotid arteries to be pulled medially, favoring occlusion by the ventral jaw of the trap.

The possums captured in this trial were all aligned in the trap opening such that the upwardly rotating striking bar would strike and clamp onto the ventral aspect of the neck. In field use, possums can be found with their necks rotated in the trap and/or having a forelimb caught between the striking bar and the neck. It is unlikely, especially when the neck is rotated, that both carotids would be totally occluded. Consequently, for a kill trap to operate effectively even with offset jaws, the target animal must, as much as possible, be vertically aligned with no limbs obstructing the striking bar.

These results show at least for brushtail possums that the configuration of trap jaws can have a significant effect on time to loss of palpebral reflexes, and significant improvements could be made by offsetting the jaws of kill-traps without the need to increase the power of the trap. The Conibear (Woodstream Corp.) range of kill-traps, which are used extensively in Canada and the USA for trapping a wide range of furbearer species, has two rotating jaws that oppose each other. With the demand from animal welfare advocates for improved kill traps, but a reluctance by trappers to use increasingly powerful traps, trap manufacturers should assess the potential for optimizing currently available traps by modifying configurations of trap jaws. For some target species such modifications might satisfy the demands for more rapid killing traps without compromising the safety of trappers.

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