R–10520

Trap Catch of Ferrets, Using Live and Dead Prey as Lures

Andrea E. Byrom, Eric B. Spurr, Grant A. Morriss, Chris W. Morse, and Cheryl E. O'Connor

Landcare Research
PO Box 69, Lincoln 8152
New Zealand

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Reviewed by:	*Approved for release by:*
Ben Reddiex Scientist Landcare Research	Phil Cowan Science Manager Biosecurity and Pest Management

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Project and Client

One possible reason why ferrets are not trappable during the period July to December is that they prefer live prey (juvenile rabbits) at this time of year. This hypothesis was investigated by Landcare Research for the Animal Health Board (Project R-10520) from March 2000 to June 2003.

Objective

To identify cost-effective and practical means of killing a minimum of 80% of female ferrets in the rabbit-prone areas of the South Island, during late winter and spring, by:

- comparing the percentage of females caught in traps with live prey as lures with the percentage of females caught in traps with dead prey as lures, in late winter/spring and summer/autumn.

Methods

The project was carried out on two rabbit-prone sites in the Mackenzie Basin during 2001 and early 2002. Two types of lures were allocated randomly on each site: ferret traps were either placed alongside a hutch containing one recently-weaned live rabbit (mean weight 441 g), or a hutch containing a dead rabbit of approximately the same size and age (mean weight 307 g). Female ferrets were radio-collared on both sites in April 2001 and capture rates of radio-collared females were compared in late winter (September 2001) and late summer (February 2002). Captures of male ferrets were also recorded.

Results

Captures of radio-collared female ferrets were higher in traps with dead rabbit as a lure than in traps with live rabbit as a lure, in both winter and summer. However, capture rates were low and these differences were not statistically significant. Ear-tagged male ferrets were also more likely to be captured in traps using dead rabbit as a lure. Again, with low numbers of ferrets captured, this difference was not significant.

In the winter field trial (September 2001), nine ferrets (5 males and 4 females) were captured on the two sites. Of these, eight were captured in traps containing a dead rabbit (89%), and one was captured in a trap containing a live rabbit. Of the 18 radio-collared female ferrets available on both sites, four were captured, of which three (75%) were captured using dead rabbits as lures.

In the summer field trial (February 2002), 87 ferrets (45 males and 42 females) were captured on the two sites. Of these, 55 were captured in traps with a dead rabbit (63%), and 32 were captured in traps with a live rabbit. Of the 13 radio-collared female ferrets available on both sites, 10 were captured. Seven (70%) were captured in traps using dead rabbit as a lure, and three were captured in traps using live rabbit as a lure. All 10 of these females had finished breeding. Of the three radio-collared females not captured in summer, one had kits and two were in breeding condition (vulva enlarged), i.e. they were still breeding.

We also looked at the number of "capture events" (captures and recaptures of all ferrets; as distinct from the actual number of ferrets captured). In winter, all ferrets captured were only captured once, so these figures are the same as results reported above. In summer, there were 152 capture events. Of these, 85 were in traps using dead rabbit as a lure (56%), and 67 were in traps using live rabbit as a lure.

Conclusions

The predicted preference for live prey in winter/spring was not supported by the results of this study. Indeed, ferrets preferred dead rabbits in both our winter and summer trials, although this preference was not statistically significant. Only four of 18 radio-collared ferrets available (22%) were captured in the winter/spring trial, which was far short of the desired 80% capture rate set by the AHB. Of those four, only one was captured using a live rabbit as a lure. In both the winter and summer trials, traps with live prey were less likely to capture a ferret than traps with dead prey as a lure.

This study does have some limitations. For example, 6-week-old weaned rabbits were used, and not milk-fed nestlings (which might be preferred by ferrets). In addition, no visual lure was used in the traps because we aimed to determine preference for the smell of live prey (6-week-old rabbits) in the strictest sense.

Several studies of the phenomenon low trappability of ferrets in winter have now been completed. One factor emerges as being an important contributor to the phenomenon: ferrets avoid traps during this critical period, the mechanism of which appears to be a neophobic response (aversion to new objects placed in the environment). The neophobic response can be partially overcome by trapping for longer periods (i.e. increasing trapping effort) and by careful placement of traps close to den entrances, but until we know the underlying biological reason for low trappability, it remains frustratingly costly and ineffective to trap ferrets in winter and spring.

Recommendations

- Attracting ferrets to traps or bait stations using fresh meat (primarily rabbit meat) is still the method of choice for ferret control.
- The Animal Health Board should continue to explore methods to overcome behavioural avoidance responses of ferrets to devices in winter and spring. Methods that do not require ferrets to encounter devices (such as the use of dogs trained to identify ferret dens) may be particularly effective.
- Based on all the recent research on winter trappability of ferrets, available evidence indicates that *trapping effort* is still the best predictor of the proportion of ferrets captured in any given ferret population. Therefore, the Animal Health Board should focus on determining the cost-effectiveness (a simple measure of contractor cost versus annual rate of recovery of a ferret population) of controlling ferrets in winter/spring compared with autumn to determine whether winter/spring trapping will ever be effective as a means of reducing ferret numbers.
- The Animal Health Board should continue to focus on investigating the underlying causes of the low trappability phenomenon, and ways to overcome it. The phenomenon of low trappability in ferrets in winter and spring seems to vary between sites, seasons and years, and we suggest collating as much data as possible from as many trappers (researchers and contractors) as possible to help determine reasons for the variation.

1. Introduction

One possible reason why ferrets are not trappable during the period July to December is that they prefer to hunt live prey (predominantly juvenile rabbits) rather than scavenge at this time of the year. This hypothesis was investigated by Landcare Research for the Animal Health Board (Project R-10520) from March 2000 to June 2003.

2. Background

Ferrets (*Mustela furo*) were introduced into New Zealand in the 1880s to control burgeoning populations of European rabbits (*Oryctolagus cuniculus*). They are now considered a vertebrate pest of both economic and conservation importance (Clapperton 2001). Ferrets are potential vectors of bovine tuberculosis (Tb), and as such may pose a significant threat to New Zealand's international beef, dairy and venison industries (Ragg et al. 1995; Lugton et al. 1997; Caley et al. 1998; Byrom 2001).

Ferrets are a domesticated form of the European polecat (*Mustela putorius*) and are generally much less trap-shy than truly wild mustelids such as stoats (*M. erminea*) (Moller et al. 1996). However, several researchers, contractors, and managers in New Zealand have observed that catchability of ferrets declines in the period July to December (Moller et al. 2002). Ferrets are also hard to control by poison baiting during this period (Spurr et al. 1997). This phenomenon of low trappability during winter has been documented in mustelid populations worldwide (Buskirk & Lindstedt 1989).

One possible reason why ferrets are more difficult to trap in the period July to December is that they may eat more live prey and less carrion, and so are less attracted to currently used baits, i.e. they prefer to obtain food by hunting rather than scavenging, resulting in lower trap catch and bait take in late winter and spring (Spurr et al. 2001). Juvenile rabbits are a highly preferred food at this time of the year (Reddiex et al. 2002). Rabbit numbers normally peak in December or January and then decline, whereas ferret numbers typically increase to a peak in March (Robson 1993; Mills 1994; Norbury & Heyward 1996). From January to June, as rabbit numbers decline and fewer young are born, ferrets may be forced to scavenge on carrion (and therefore baits, if available) to supplement their diet. Young rabbits become available again from about July, and it is at this time that bait consumption by ferrets declines. If per capita availability of preferred prey (young rabbits) is highest in July–December, there would be a reduced need to scavenge, and this could explain the lower trap catch and consumption of baits by ferrets at this time.

Two recent models make conflicting predictions about the best season to trap ferrets (summer/autumn or winter/spring). Roberts et al. (1999) suggested that killing ferrets in winter and spring may be more effective at reducing the next generation of ferrets than culling during summer and autumn (although they also concluded that autumn culling might be a better option when ferrets are at naturally low densities). Conversely, Barlow & Norbury (2001) concluded that autumn culling was generally better if control operations are

episodic (they are often annual for a 10-night period) and not continuous. Even though the models conflict in their conclusions, there is at least some evidence from both models that culling ferrets during winter and spring might be effective under certain conditions. Methods for overcoming low trappability of ferrets in winter and spring are therefore urgently needed.

3. Objectives

To identify cost-effective and practical means of killing a minimum of 80% of female ferrets in the rabbit-prone areas of the South Island, during late winter and spring, by:

- comparing the percentage of females caught in traps with live prey as lures with the percentage of females caught in traps with dead prey as lures, in late winter/spring and summer/autumn.

4. Methods

The study was conducted on rabbit-prone sites in the Mackenzie Basin, South Canterbury, on The Wolds and Simons Hills high-country stations. The area of each study site was 1600–1900 ha.

Trapping of ferrets on both sites commenced in April 2001. Ferrets were live-trapped in cantilever plastic box traps (manufactured by M. Holden, Amberley), using rabbit meat as a lure, and ear-tagged to identify individuals. At least 19 adult female ferrets were radio-collared in April 2001 on each site with 30-g Sirtrack ferret collars (Table 1).

Radio-collared ferrets were tracked twice during winter 2001 to determine their survival, and to identify any ferrets that shifted their home ranges outside the study sites. Not all radio-collared ferrets survived the winter, and some ferrets moved off the treatment sites. At the beginning of the winter field trial, 12 radio-collared female ferrets were located on The Wolds and 11 were located on Simons Hills. At the beginning of the summer field trial, 8 radio-collared female ferrets were located on The Wolds and 6 were located on Simons Hills (Table 1).

Table 1 Number of adult female ferrets radio-collared on two high-country stations in the Mackenzie Basin, and number remaining on each site for the field trials.

Site	Number of female ferrets collared in April 2001	Sample size for winter trial in September 2001	Sample size for summer trial in February 2002
The Wolds	23	12	8
Simons Hills	19	11	6
Total available female ferrets	42	18(23)*	13(14)*

*Five ferrets in the winter trial and one in the summer trial were re-located but no longer had home ranges on the study sites. Those ferrets were therefore excluded from subsequent analyses. Further reduction in numbers of collared ferrets available on the study sites between April and September 2001, and September 2001 and February 2002, was due to mortality.

The winter field trial commenced on 20 September 2001 and the summer trial on 22 February 2002. (We call these trials the "winter" and "summer" trials, respectively, in this report). At both sites, 100 cantilever plastic box traps were set out in a grid pattern at spacings of 300–500 m so that all resident ferrets had an equal probability of capture.

Each ferret trap was attached to a rabbit hutch capable of housing a live rabbit for 5 days (Fig. 1). Each hutch contained either a live rabbit or a whole dead rabbit as a lure, with whole dead rabbits placed on the floor in the centre of the hutch. It was not possible to have separate replicates of each treatment because of the cost, so treatments (live or dead rabbits) were assigned randomly to traps at both sites. Recently weaned, 6-week-old rabbits were bred in the Landcare Research Animal Facility at Lincoln, with the timing of rabbit breeding coinciding with the winter and summer trials. Rabbits bred at the facility were either transported alive to the field sites, or were humanely killed by dislocation of the neck vertebrae and used as the "dead" bait. The average weight of rabbits used in the winter trial was 441 g, and the average weight of rabbits used in the summer trial was 307 g. This project was approved by the Landcare Research Animal Ethics Committee (Approval No. 00/5/6). Details of rabbit husbandry are given in Appendix 1.

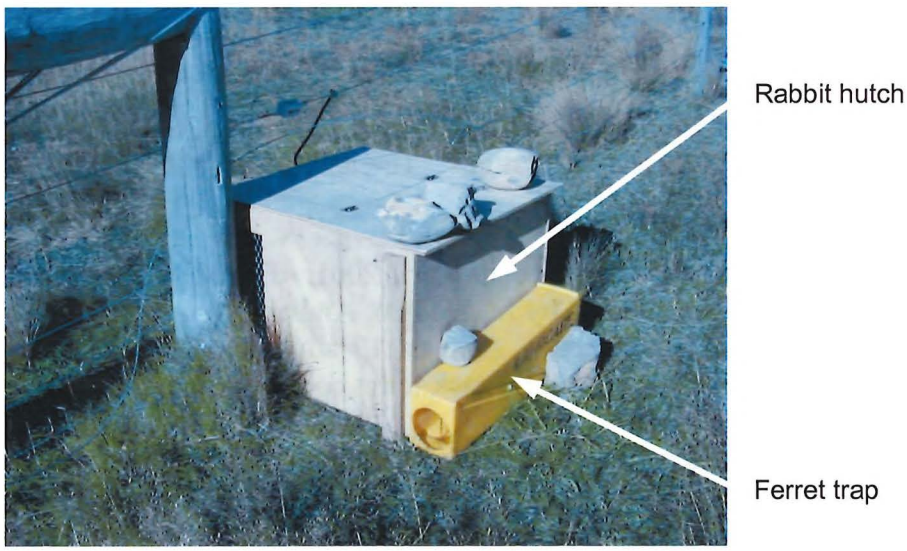

Fig. 1 Ferret trap adjacent to rabbit hutch containing either a live or dead rabbit as a lure. Stones were used as weights on the roof of the rabbit hutch and on the ferret trap.

Traps at both sites were set for 5 nights during the trials. All ferrets captured were ear-tagged and released if they were not already marked, and capture rates of radio-collared females were compared in winter and summer. Responses of ferrets to live and dead prey as lures were similar for each site, so in the following sections we present combined results. We examined trappability of ferrets in winter and summer by examining four measures of the success of "live" and "dead" lures:

1. The *percentage of radio-collared female ferrets captured*, and the rate at which they were captured, in winter and summer. Radio-collared females were used because they provided a known sample of available ferrets. We predicted that traps with live prey as a lure would capture a greater proportion of this known sample of females, at a faster

rate, than traps with dead prey as a lure. We compared the percentage of radio-collared females captured with "live" and "dead" prey using logistic regression.

2. The *total number of ferrets captured* (both males and females) with live and dead lures in winter and summer. We predicted that, if ferrets of either sex preferred live prey as a lure, more ferrets would be captured overall in traps containing live prey as a lure. We also predicted that more initial captures of ferrets would occur in "live" compared to "dead" traps.
3. The *cumulative number of capture events of ferrets*, both males and females, in winter and summer. We examined the total number of captures, including recaptures, because we were interested in whether ferrets would be more likely to enter (and continue to re-enter) traps with live prey as lures.
4. The *number of ear-tagged male ferrets captured* in traps with live and dead prey as lures in winter and summer. A key assumption in our comparison of captures of ear-tagged male ferrets between the two lure types is that the number of male ferrets was approximately similar between the two sites. We predicted that male ferrets might also prefer live prey as lures in winter.

The *main objective* of this study was to focus on the measure of trappability of radio-collared female ferrets ([1] above). However, the other results obtained from captures and recaptures of ferrets of both sexes ([2] – [4] above) also highlight aspects of the winter trappability of ferrets that we thought were important enough to warrant examination.

5. Results

5.1 Percentage of radio-collared female ferrets captured

In the winter field trial, traps containing live prey as a lure captured less than 6% of the available radio-collared female ferrets (1 of a total of 18 collared females available on the two sites). Traps containing dead rabbits as a lure did better, capturing 17% of available collared females (3 of 18) (Fig. 2). Although traps with dead prey captured three times as many ferrets as traps with live prey, this difference was not statistically significant (Fisher's exact test; $P = 0.60$), given the small number of ferrets captured.

In the summer field trial, traps containing live prey as a lure captured about 23% of available female ferrets (3 of 13), whereas traps containing dead prey captured 54% (7 of 13). This difference was not significant (Fisher's exact test; $P = 0.23$). All 10 females captured had finished breeding. Of the three radio-collared females not captured, one had kits and two were in breeding condition (vulva enlarged), i.e. they were still breeding. (We know the breeding status of these three females because they were later dug out of their dens in order to retrieve their radio collars).

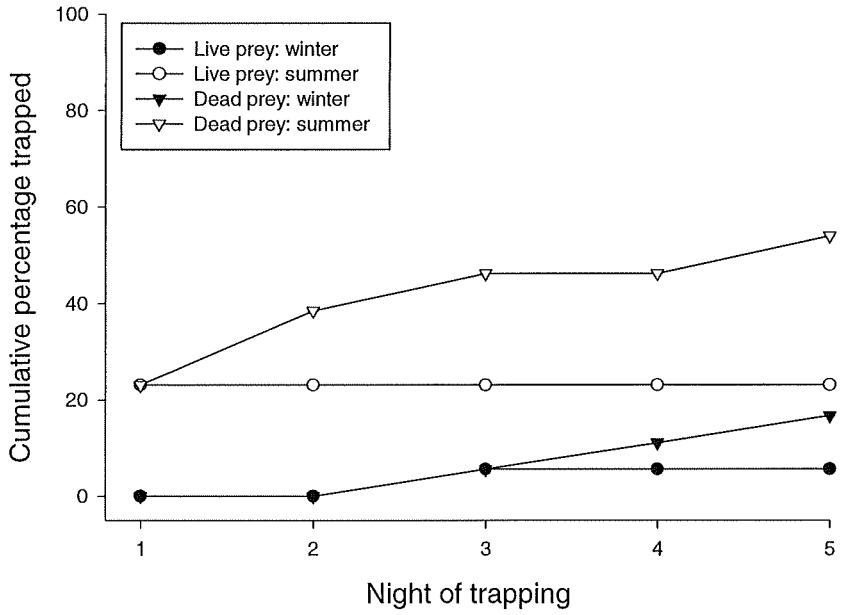

Fig. 2 Cumulative capture rates of radio-collared female ferrets in traps containing live and dead prey as lures, in winter and summer.

5.2 Total number of individual ferrets captured

The total number of different ferrets captured after 5 nights (radio-collared, ear-tagged, and unmarked ferrets excluding recaptures) was slightly higher in traps containing dead rabbits than traps containing live rabbits as a lure (Table 2). This difference was not significant in winter (Fisher's exact test; $P = 0.41$) or summer (Fisher's exact test; $P = 0.51$). The *only* females captured in our winter trial had radio-transmitters, indicating that low sample sizes may have accounted for the lack of statistical significance in winter.

These figures only account for the lure type (live or dead rabbit) in traps that *first* captured any given ferret. Ferrets that were retrapped during the study in summer sometimes went for the other type of lure on subsequent trapping. Therefore, this result also means that ferrets were more likely to be captured *first* in traps containing dead prey as a lure, rather than live prey.

Table 2 Total number of individual ferrets (both males and females) caught in traps with live and dead prey as lures in winter and summer.

	Winter trial			Summer trial		
	Males	Females	Total	Males	Females	Total
Live prey	0	1	1	15	17	32
Dead prey	5	3	8	30	25	55

5.3 Cumulative number of ferret captures ("capture events")

The cumulative number of capture events of ferrets over 5 nights (both sexes combined and first captures and recaptures combined) was slightly higher in traps with dead rabbit as lures than in traps with live rabbit as lures, in both winter and summer (Fig. 3). In winter, 8 of 9 capture events (89%) were in traps using dead rabbit and one was in a trap with live rabbit. In summer, 85 of 152 capture events (56%) were in traps using dead rabbit as a lure, and 67 were in traps using live rabbit as a lure. Ferrets were more likely to enter and re-enter traps with dead prey as lures, particularly in the summer trial. This difference was close to statistical significance (Fisher's exact test; $P = 0.08$).

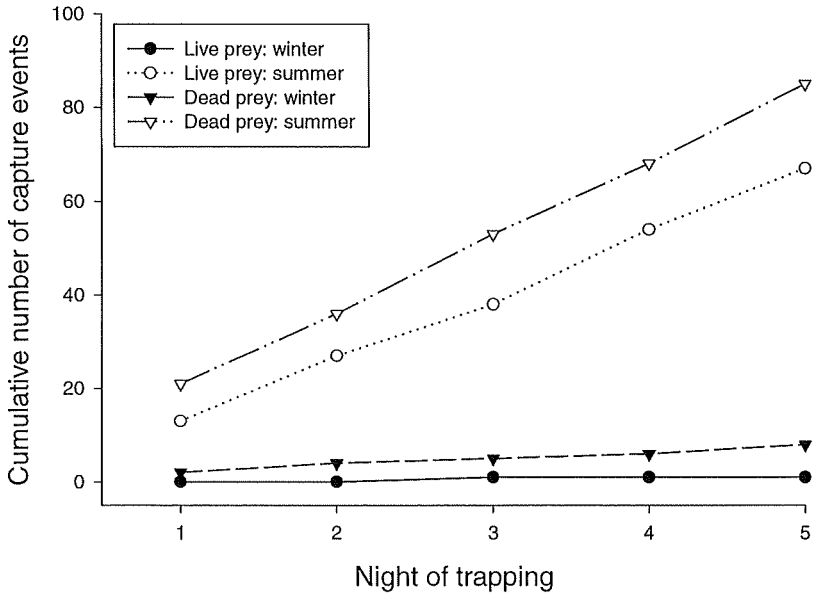

Fig. 3 Cumulative number of "capture events" of ferrets (males and females, first captures and recaptures combined) in traps with live or dead prey as lures in winter and summer.

We examined the capture events of male and female ferrets separately, to determine whether either sex was more or less likely to enter traps with live or dead prey as lures. In the winter trial, only one female ferret was captured. In summer, 44 of 85 (52%) capture events with dead prey were of female ferrets. In addition, 44 of 82 (54%) capture events of female ferrets were made using dead prey. Both sexes thus contributed equally to the observed preference for dead prey; $\chi^2 = 0.20$; $P = 0.66$; Table 3).

Table 3 Total number of capture events[1] (initial captures and recaptures) of male and female ferrets in traps with live and dead prey as lures in winter and summer.

	Winter trial			Summer trial		
	Males	Females	Total	Males	Females	Total
Live prey	0	1	1	29	38	67
Dead prey	5	3	8	41	44	85

[1] Note that these figures do not represent the number of individual ferrets captured (those results are presented in Table 2 above).

We also examined new captures (first-capture events) and recaptures (subsequent capture events) separately to determine whether first captures or recaptures of ferrets were responsible for the observed preference for dead prey in both seasons. In winter, all ferrets were only captured once. In summer, first captures and recaptures contributed approximately equally to the observed difference in preference between live and dead prey as lures (Table 4). Hence, overall, there was no evidence that a ferret's capture history influenced a preference for dead prey. There was also no indication that, having been captured with live prey as a lure, a ferret was more likely to be recaptured using live prey.

Table 4 Total number of capture events of ferrets in winter and summer, by first-capture or recapture.

Trap type	Winter			Summer		
	First captures	Recaptures	Total	First captures	Recaptures	Total
Live prey	1	0	1	32	35	67
Dead prey	8	0	8	55	30	85

5.4 Number of ear-tagged male ferrets captured

In both winter and summer, the total number of ear-tagged male ferrets was greater in traps containing dead prey as lures (Fig. 4), although this difference was not significant (Fisher's exact test; $P = 0.45$). The observation that traps with dead rabbits captured more male ferrets should therefore be treated with caution. Nevertheless, it does concur with the similar result obtained for female ferrets.

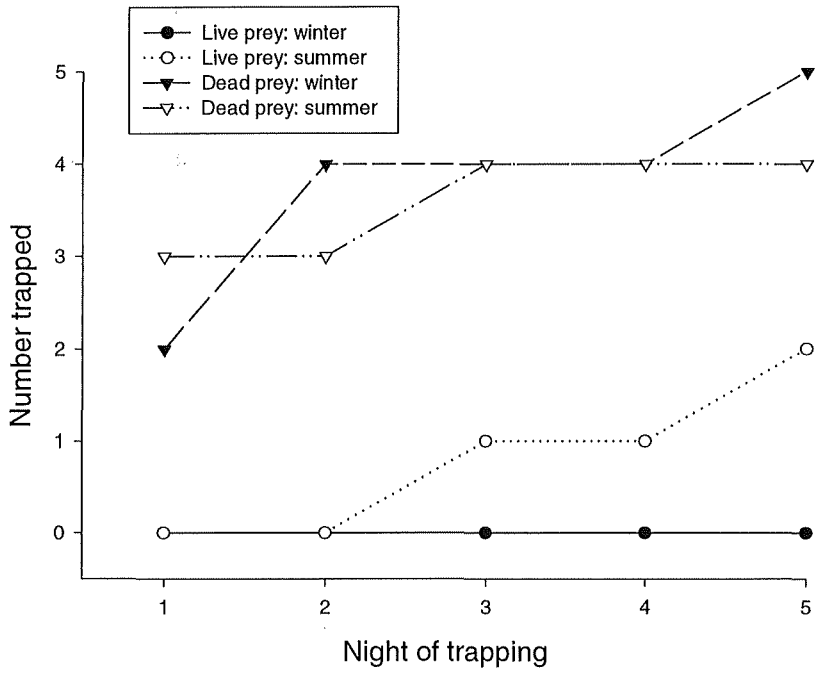

Fig. 4 Cumulative number of ear-tagged male ferrets captured in traps with live and dead prey as lures in winter and summer.

6. Conclusions

6.1 Discussion of results from the study

This project was established to test whether ferrets prefer live prey in late winter and spring when juvenile rabbits become available, and are less trappable at that time because of that preference. No strong preference for live 6-week-old rabbits during the period of low trappability (late winter and spring) was observed in our study, and using these live prey as lures did not achieve the required 80% reduction in the population of available radio-collared female ferrets during our winter trial. An 80% capture rate was also not achieved using dead 6-week-old rabbits. All capture data indicated that ferrets have a slight preference for dead prey and not live prey as lures, in both winter and summer, or at least, were willing to enter traps with both live and dead prey as lures on both of our sites.

Three female ferrets in our summer trial were in breeding condition and were not trapped. Anecdotal evidence from a number of previous research studies, and from contractors, suggests that low trappability in ferrets might be related to the onset of oestrus, breeding, and lactation. Data from this study tends corroborate this view.

The rationale for this study was to examine the possibility that ferrets prefer live prey during winter and spring, and to decide whether this preference might warrant alternative measures of controlling ferrets, such as secondary poisoning through poisoning rabbits, or using a reduction in ferrets' prey base (rabbit control) as a means of forcing ferrets to scavenge on baits at this time of the year. *The aim of this study was not to recommend the use of live prey lures as a management option for ferrets.* As it turned out, newly-weaned live rabbits were not preferred by ferrets, so these options do not need to be investigated further.

We chose to address the hypothesised preference for live prey by ferrets directly, by measuring the response of a known sample of ferrets to live and dead prey as lures. An alternative method might have been to mark live and dead rabbits in the field with different markers (e.g. rhodamine B for live rabbits and iophenoxic acid for rabbit carcasses) in order to determine ferret preferences. This approach would have posed its own set of problems (the most obvious being that it would have been difficult to mark all rabbits and therefore detect the markers in ferrets). We think that the approach we took was as reliable as any other method of measuring prey preference in ferrets in winter.

We obtained our results despite the fact that the dead rabbits placed in hutches were usually not bloody, as a chunk of fresh bait would be (i.e. the smell of fresh meat was not what was attracting ferrets to the trap). Therefore, our study could be regarded as a conservative way to determine which type of lure was preferred, because dead rabbits were preferred despite not having the smell of fresh blood associated with them.

We should emphasise that the above conclusions (focussing on *bait preference*) should not be confused with the *numerical response* of ferret populations to changes in their prey base (e.g. a reduction in ferret numbers after rabbit control). A longer-term reduction in ferret populations, and slower rates of recovery of ferret populations, might still be achieved by reducing rabbit populations. This is being investigated by G. Norbury and A. Byrom (project

R-10591). Preliminary results suggest that large-scale (>2500 ha) rabbit control operations may reduce ferret numbers for more than one season. Indeed, rabbit control concurrent with ferret control may turn out to be particularly effective if ferrets are forced to scavenge for baits when rabbit numbers are scarce.

6.2 Limitations of the study

One possible reason why we did not reach the desired 80% capture rate is that our traps did not contain a visual lure. However, due to animal ethics requirements, the live rabbits used in our trials had to be able to "escape" visually from the ferret. Perhaps if we had placed something visual in each trap, we might have increased capture rates, but we were able only to use the *smell* of live or dead prey (to determine preference in the strictest sense). Nevertheless, this situation is probably analagous to a ferret searching for rabbit nestlings below ground, with no immediate visual cues.

Second, rabbits used in this trial were older than the milk-fed nestlings often preferred by ferrets (Reddiex et al. 2002). The newly-weaned juveniles we used may have smelled different from milk-fed nestlings. We did not attempt to use milk-fed nestlings in this study because it would not have been possible to keep them alive in the hutches.

6.3 Integration of results with other recent research on winter behaviour of ferrets

Three AHB-funded studies have now investigated the phenomenon of low trappability of ferrets in winter and spring: (1) Ferret neophobia to traps, R-10508 (Byrom et al. 2002); (2) Home range, movement and activity patterns of female ferrets – testing hypotheses relating to low trappability in winter and spring, R-80509 (Ragg 2002); and (3) Trap catch of ferrets using live and dead prey as lures, R-10520 (this study). In combination, the three studies make a significant contribution to our understanding of the low trappability issue, and their importance should not be underestimated despite all having produced relatively inconclusive results.

We now know a great deal about what factors *do not* cause the phenomenon of low trappability:

1. Ferret home range sizes do not change (reduce) significantly during the low trappability period (Ragg 2002).
2. Core home range areas reduce slightly, but not significantly enough to affect encounter rates with devices (Ragg 2002).
3. Activity levels actually increase slightly during the period of low trappability (Ragg 2002).
4. Ferrets exhibit no strong preference for live prey (6-week-old weaned juvenile rabbits) in traps during the low trappability period (this study).

The studies have pointed to one critical factor affecting low trappability of ferrets during winter and spring:

1. Female ferrets do exhibit some avoidance of devices (traps) placed at den entrances during the low trappability period (Ragg 2002). This avoidance is probably due, at least in part, to a neophobic response (aversion by ferrets to novel objects in their

environment) (Byrom et al. 2002). Careful placement of traps in the environment (e.g. close to den entrances or in areas frequented by ferrets), and trapping for longer periods of time, can partly but not completely overcome this avoidance behaviour.

It has been suggested that low trappability of ferrets in winter and spring varies between years (more pronounced in some years than others), within seasons (earlier in some seasons and later in others), and among areas (more pronounced at some locations than others). These variations have been observed by contractors (M. Holden, C. Small, P. and M. Dawson, pers. comm.) and researchers (J. Ragg, H. Moller, P. Caley, pers. comm., and E. Spurr and A. Byrom, pers. obs.). Collating all available data would determine how universal the phenomenon is, and whether existing data can be used to operate with testable hypotheses.

The phenomenon of low trappability can likely be overcome by more intense trapping effort and careful placement of traps, but until we know the underlying biological reason for observed behavioural changes, it remains frustratingly costly and ineffective to trap ferrets in winter and spring. Methods that do not require ferrets to encounter devices, or do not require them to be attracted/lured to devices (such as the use of dogs trained to identify ferret dens) may be a particularly effective alternative.

7. Recommendations

- Attracting ferrets to traps or bait stations using fresh meat (primarily rabbit meat) is still the method of choice for ferret control.
- The Animal Health Board should continue to explore methods to overcome behavioural avoidance responses of ferrets to devices in winter and spring. Methods that do not require ferrets to encounter devices (such as the use of dogs trained to identify ferret dens) may be particularly effective.
- Based on all the recent research on winter trappability of ferrets, available evidence indicates that *trapping effort* is still the best predictor of the proportion of ferrets captured in any given ferret population. Therefore, the Animal Health Board should focus on determining the cost-effectiveness (a simple measure of contractor cost versus annual rate of recovery of a ferret population) of controlling ferrets in winter/spring compared with autumn to determine whether winter/spring trapping will ever be effective as a means of reducing ferret numbers.
- The Animal Health Board should continue to focus on investigating the underlying causes of the low trappability phenomenon, and ways to overcome it. The phenomenon of low trappability in ferrets in winter and spring seems to vary between sites, seasons and years, and we suggest collating as much data as possible from as many trappers (researchers and contractors) as possible to help determine reasons for the variation.

8. Acknowledgements

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9. References

Barlow, N. D.; Norbury, G. L. 2001: A simple model for ferret population dynamics and control in semi-arid New Zealand habitats. *Wildlife Research 28*: 87–94.

Buskirk, S. W.; Lindstedt, S. L. 1989: Sex biases in trapped samples of mustelidae. *Journal of Mammalogy 70*: 88–97.

Byrom, A. E. 2001: Ferrets as vectors of bovine Tb: a review. *Proceedings of the New Zealand Society of Animal Production 61*: 60–63.

Byrom, A. E., Spurr, E. B.; O'Connor, C. E. 2002: Ferret neophobia to traps. Landcare Research Contract Report LC0102/082 (unpublished).

Caley, P.; Morley, C.; Thomas, M. 1998: Effects of ferret control on cattle reactor incidence, ferret Tb prevalence, and rabbit numbers – the North Canterbury ferret control trials. Unpublished report LC9899/044, Landcare Research.

Clapperton, B. K. 2001: Advances in New Zealand Mammology 1990 – 2000: Feral Ferret. Journal of the Royal Society of New Zealand 31: 185-203.

Lugton, I. W.; Wobeser, G.; Morris, R. S.; Caley, P. 1997: Epidemiology of *Mycobacterium bovis* infection in feral ferrets (*Mustela furo*) in New Zealand: I. Pathology and diagnosis. *New Zealand Veterinary Journal 45*: 140–150.

Mills, R. G. 1994: Rabbit predators in the semi-arid high country of the South Island of New Zealand. MSc thesis, Lincoln University, New Zealand.

Moller, H.; Norbury, G.; King, C. M. 1996: Ecological and behavioural constraints to effective control of ferrets (*Mustela furo*). *The Royal Society of New Zealand Miscellaneous Series 36*: 78–84.

Moller, H., Ragg, J. R.; Bowman, R.; Hunter, M.; Reed, C. 2002: Improved monitoring and control of ferret abundance for efficient bovine tuberculosis mitigation. Ecosystems Consultants Report No. 23: 187 p.

Norbury, G.; Heyward, R. 1996: The response of ferrets to rabbit control. *In*: Ferrets as vectors of tuberculosis and threats to conservation. *The Royal Society of New Zealand Miscellaneous Series 36*: 30–33.

Ragg, J. R. 2002: Home range, movement and activity patterns of female ferrets: testing hypotheses relating to low trappability in winter and spring. Report prepared for Animal Health Board Project No. R-80509.

Ragg, J. R.; Moller, H.; Waldrup, K. A. 1995: The prevalence of bovine tuberculosis (*Mycobacterium bovis*) infections in feral populations of cats (*Felis catus*), ferrets (*Mustela furo*) and stoats (*Mustela erminea*) in Otago and Southland, New Zealand. *New Zealand Veterinary Journal 43*: 333–337.

Reddiex, B.; Hickling, G. J.; Norbury, G. L; Frampton, C. M. 2002: Effects of predation and rabbit haemorrhagic disease on population dynamics of rabbits (*Oryctolagus cuniculus*) in North Canterbury, New Zealand. *Wildlife Research 29*: 627–633.

Roberts, M. G.; Kao, R. R.; Moller, H.; Norbury, G. L.; Ragg, J. R. 1999: The optimal control of ferret populations. Unpublished report to the Animal Health Board No. R-30496.

Robson, D. 1993: Natural mortality of juvenile rabbits (*Oryctolagus cuniculus*), in North Canterbury, New Zealand. *Wildlife Research 20*: 815–831.

Spurr, E. B.; Morse, C. W.; Eason, C. T. 1997: Poison-baiting of ferrets in winter. Landcare Research Contract Report LC9798/67 (unpublished), 15 p.

Spurr, E. B.; O'Connor, C. E.; Byrom, A. E. 2001: Review of research on improving the effectiveness of ferret control in winter and spring. Proceedings of the 12th Australasian Vertebrate Pest Conference. Pp. 353–357.

10. Appendices

Appendix 1 Details of housing and treatment of rabbits

We designed a rabbit hutch made of plywood, capable of housing a rabbit for a 5-day period (Fig. 5). The aim was to adequately protect the rabbit visually from a ferret, but also allow the scent of the rabbit to emanate from the hutch, most strongly towards the "capture" end of the ferret trap, i.e. to encourage the ferret to move down the full length of the ferret trap.

Each rabbit hutch was substantially larger than the minimum dimensions required for housing laboratory rabbits in both the UK and USA. Air vents (in the form of a strip of wire mesh; Fig. 6) were placed on two sides of the hutch to ensure adequate ventilation. Each rabbit had access to an internal housing that they could move into if necessary, which adequately protected the rabbit visually from a ferret. The plywood roof of the rabbit hutch was hinged to facilitate checking the status of the rabbit and its food/water supply. The floor was made of plywood. The plywood hutchs were transported to the field in pieces (which allowed them to be transported flat) and assembled in situ.

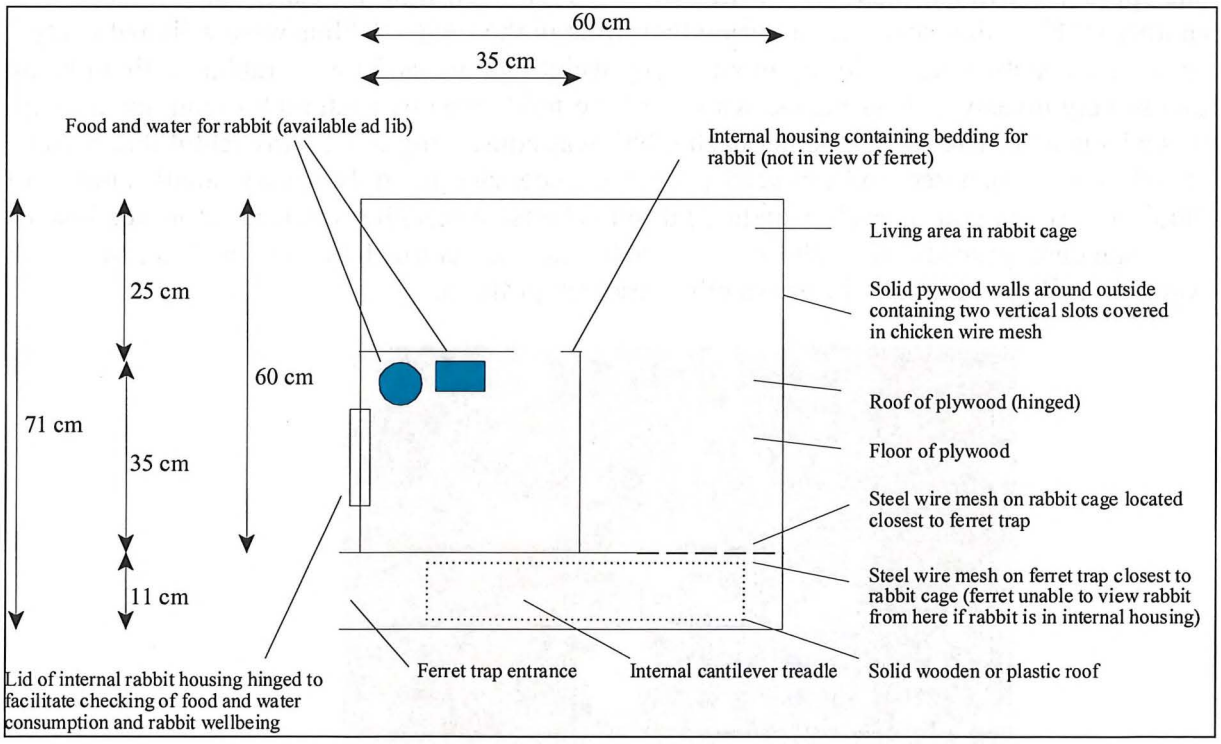

Fig. 5 Plan view of rabbit hutch with ferret trap attached (see also Fig. 1).

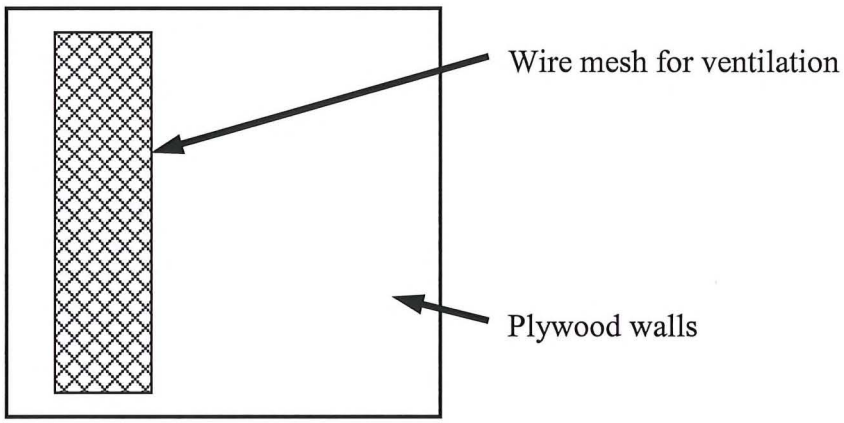

Fig. 6 Side view of one wall of the rabbit hutch to show detail of the vertical slot for ventilation.

All live rabbits were fed a "maintenance diet" of approximately 100 g of a purpose-made rabbit pellet (Weston Animal Nutrition, Rangiora) and 50 to 100 ml of water per day, plus one apple and two carrots (Fig. 7). Rabbits were removed from the hutch and replaced with another rabbit if they lost weight during their time in the field. Rabbits were weighed every 2 days. This enabled us to closely monitor any weight gain/loss for each rabbit, without being excessively invasive. A visual assessment of the food eaten by each rabbit (and noted daily) was adequate to determine whether each rabbit was consuming food. Any rabbit that became unwell was euthanased and replaced (this was necessary for only a very small number of rabbits). At the end of each 5-night trial, all rabbits were either euthanased in accordance with standard procedures at the end of each trial, or returned to the Landcare Research Animal Facility at Lincoln for use in other research projects.

Fig. 7 Food and water were provided daily to rabbits housed in the hutches.