Optimizing the ratio of captures to trapping effort in a black rat *Rattus rattus* control programme in New Zealand

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SUMMARY

The ratio of captures to unit effort is an important cost/benefit measure for volunteer pest control programmes. We describe an experiment designed to investigate the use of pre-feeding and trap pulsing as possible means of increasing this ratio. In 20 traps locked-open and pre-fed with non-toxic pellets for five days, the same number of black rats was caught over the next 5 days as in 20 non pre-fed traps set for the whole 10 days (32 rats each). Allowing for successful traps being unavailable for an average of half a night each, the capture rate in the pre-fed traps was 47% over five days, more than double that in the non pre-fed traps set for twice as long (total 19% in 10 days).

BACKGROUND

Black rats *Rattus rattus* are by far the most abundant non-native, invasive species in forests of the North Island of New Zealand. Many local pest management groups use conventional low-level trapping operations, with standard single-catch traps permanently set but not usually inspected more often than weekly. The main problem of single-catch traps (which, when set off, cannot catch again until re-set at the next inspection) is currently being addressed by new multi-catch traps now being developed. But a further problem remains: individual rats may vary in their reactions to traps, and some that have had a near escape in the past may be more trap-shy than others.

We predict that the ratio of trapping effort to capture rate can be improved, and avoidance can be detected and mitigated to some extent, by periodic pre-feeding alternating with trap pulsing. Pre-feeding attracts the attention of rats, increasing trap visit rate and potentially increasing the chances of catching the especially experienced and trap-shy rats that may escape a normal, low-level trap regime. Trap pulsing is the setting of traps for a short period following pre-feeding. This reduces the effort required in trap monitoring by volunteers, because high capture rates can be achieved when the traps are set, alternating with periods when no trap checking is required.

With the help of the community-led Pukawa Wildlife Management Trust (PWMT), based on the south-western edge of Lake Taupo, in the central North Island of New Zealand (King & Scurr 2013), a short experiment was run in December 2012, designed to investigate whether improvements in capture rate could be achieved by the use of a pre-feeding strategy.

ACTION

For 10 days, from 4th December 2012, an experimental trap line was established at Waihi Kahakahroa 3B2A, a previously unmanaged block of forested Maori land 2 km to the south of the Trust's 50 ha management area. Waihi Kahakahroa 3B2A is typical of forest fragments in the North Island where there has been no recent pest control.

The exact same experiment was run in the Pukawa management area over the following 10 days to determine whether either method was effective in an area where a degree of learned trap avoidance might have developed in rats over the previous 10 years of the Trust's conventional operations. For this experiment, a range of standard methods, widely used to control and monitor pest populations in New Zealand, was deployed in both areas.

1. DOC 200 traps. These are approved humane traps (Warburton *et al.* 2008), which are set in a wooden box. The bait is placed in the back of the box, where it can be seen and sniffed from outside through a back wall of wire mesh, but not reached except by entering a small hole in the front mesh and walking across the trap treadle. These traps seldom fail to catch an animal that enters the box, and they kill swiftly. But, like all single-action traps, once set off they cannot catch again until re-set. Estimates of trap success are conventionally calculated as the number of captures per 100 trap-nights, after correcting for the number of sprung traps unavailable to the second and subsequent visitors in a night by subtracting half a trap-night for every capture (Cunningham & Moors 1983).
2. Tracking tunnels. Black plastic tunnels and pre-inked Black Trakka© cards are supplied by Gotcha Traps, Auckland (http://www.gotchatraps.co.nz/). Previous research suggests that a one-night tracking index taken immediately before trapping begins can reliably indicate the approximate population density of rats in North Island bush in summer (Innes *et al.* 2010).
3. WaxTags© http://www.nopests.co.nz consist of a small block of wax containing an attractive scent, on which animals frequently leave distinguishable tooth marks. The wax is attached to a plastic tag which is nailed to a tree. The system was designed for monitoring possums, and has been confirmed as accurate by calibration against conventional density estimates (Thomas *et al.* 2007). It also detects tooth marks left by rats.
4. A further measure of trap avoidance was added during this experiment by the deployment of fake bird-nests, with both real and artificial eggs, as described by King & Scurr (2013).

On the night of 4-5th December 2012, 15 tracking tunnels were set 50 m apart, before any trapping began, to confirm that rats

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were indeed present in the expected numbers. Then the new line of 40 DOC 200 traps was set out at 15 m intervals.

Half the 40 new traps (one at every alternate site) were set immediately in the normal way from the nights of 5-6th to 9-10th December, and half were pre-fed (five days of pre-feeding with non-toxic PRO cereal pellets for possums (Pestoff Ltd, Wanganui) but locked open, then set to catch for five nights, 10-11th to 14-15th December). Daily records were collected to show which strategy caught most rats per unit effort. Daily kills were recorded for each trap site, plus the body weight and sex of dead rats.

To check for trap avoidance, a single WaxTag© was attached to each box, and one randomly on a tree between each trap box. Each morning for the whole 10 consecutive days the traps and wax tags were checked, cleared, and the non-toxic pre-feed pellets or WaxTag© replaced as necessary. The same procedure was then repeated in the Pukawa management area.

CONSEQUENCES

Tracking tunnels recorded four visits by rats (27%) and one unidentified animal. Tracking index values up to about 30% correspond to a population of 3-5 rats/ha over the first six nights of trapping, a suitable target density for this experiment.

The new trap line captured 64 rats over the 10 nights (300 trap-nights), plus two hedgehogs and one stoat (all caught in different non pre-fed traps, on 5, 8 and 9th December respectively).

In the 20 traps set for the first five days without pre-feeding, there was a steady increase in total number of catches up to night five, 9th December, as rats found the newly set trap line (Table 1). Allowing for successful traps being unavailable for an average of half a night each, the capture rate was 24 rats in 76 trap-nights, 31.5% (Table 1). Eight rats approached a trap but left only tooth marks or scats, and fewer than 20 fake bird-nests were damaged.

Meanwhile, at the alternate trap sites that were pre-fed, all within 15 m of the nearest non pre-feeding site, rats left tooth marks 27 times, and crossed over the locked traps to take the pre-feed pellets 68 times.

During the second five nights of the study the capture rate in the 20 non-fed traps fell by two-thirds, to only eight rats, giving a total of 32 catches for 10 days of effort (168 C/TN, 19%; Table 1). Wax tags recorded only 13 visits by rats that did not enter, but more than 60 fake bird-nests were damaged (Table 1).

After the 20 traps with pre-feeding treatment were set to catch for the first time on the 6th night, twice as many rats were caught per trap-night in half the time (32 over 5 nights, as compared with 32 over 10 nights). Allowing for successful traps being unavailable for an average of half a night each, the capture rate in the pre-fed traps was 47% over five days, more than double the rate in the non pre-fed traps set for twice as long (total 19% in 10 days; Table 1).

Among 36 male rats and 26 females caught, the great majority were old adults, with a few young adults and no juveniles (Table 2). The old adults were full grown, and almost all would have been in reproductive condition, judging by previous analyses of rats from comparable bush areas in summer (King *et al.* 2011). The absence of juveniles indicates that few of the current season's young had yet entered the trappable population. It is not known what makes rats 'trappable', but it is clear that some rats avoid traps, which indicates that those that are caught do not necessarily represent the whole population

When the equivalent experiment was run two weeks later using identical methods within the Pukawa management area, no rats at all were captured in 130 trap-nights. Wax tags detected the presence of a rat at one nest site and at two trap sites, one night each, and possums at three sites, one night each, but there was no other evidence of trap avoidance. Nine tracking tunnels set for one night (14-15th December) recorded three visits by mice but no rats. From evidence presented by

Table 1. Rat captures during December 2012. The standard index of density (captures/100 trap-nights, C/100TN) and results of the deployment of fake bird-nests in the same area, are estimated separately for traps with and without the pre-feeding treatment.

	First 5 nights, alternate traps set			**Second 5 nights, all traps set**		
No previous control	**Non pre-fed sites**	**Pre-fed sites**	**Rats caught, C/100TN[4]**	**Non pre-fed sites**	**Pre-fed sites**	**Rats caught C/100TN**
N traps (TN)	20 traps (100TN), set	20 traps, none set		20 traps (100 TN), set	20 traps (100 TN) set	
Misses[1]	8	27		13	10	
Lag [2]	26	-		12	8	
Visits[3]	-	68		-	-	
Rats caught/night						
No Pre-feed	3,2,6,4,9 (24)	-	24/76 (31.5%)	3,0,2,2,1 (8)		8/92 (8.7%) Total 32/168 (19%)
Pre-feed	-	-			12,11,4,3,2 (32)	32/68 (47%)
Fake bird-nests damaged	18	15		62	69	

[1] Total available trap-nights on which visiting rats failed to enter a trap, but left tooth marks or scats
[2] Total available trap-nights recorded by the 15 eventually successful traps before they caught their first rats
[3] Total non-available trap-nights on which a locked trap was entered, and the pre-feed taken
[4] Corrected for unavailable traps by the formula: C*100/TN-C, hence 2400/100-24 =31.5

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Table 2. Distribution of black rats caught in the experimental area by weight categories, which are correlated with age. Young adults are sexually mature, but genetic testing and analyses of comparable summer populations shows that most breeding is done by the old adults (King *et al.* 2011).

		Body weight range (g)	Number of rats
Males			
1	Juveniles	<110	0
2	Young adults	110-140	12
3	Old adults	>140	24
			36
Females			
1	Juveniles	<80	0
2	Young adults	80-120	8
3	Old adults	>120	18
			26

King & Scurr (2013) we concluded that there were not enough rats remaining on the management area to test whether pre-feeding would be more effective than the standard routine in catching trap-shy rats. The experiment did not run long enough to test whether the few rats detected by wax tags might eventually have been caught.

DISCUSSION

The results suggest that a pulsed system in which all traps are pre-fed with edible, non-toxic pellets (not merely with a lure), locked open for a week, and then set and visited frequently, preferably daily, for the next week, can significantly increase the number of captures per unit effort (47% over five days, compared with 19% over 10 days; Table 1).

When volunteers trap, they put in a lot of physical effort to bait, set and inspect the traps; their greatest satisfaction is likely to be correlated with recording high numbers of catches per inspection round. Switching to pulsed trapping with pre-feeding should distribute the cost in volunteer effort in short intensive bursts rather than as less frequent visits over a longer term, but the outcome should be more satisfying to the volunteers. In this trial, with daily inspections, the same total number of rats was caught in 20 pre-fed traps set for five nights as in 20 traps set without pre-feeding for twice as long. But the difference in catch rate by the traps available was much more than 100% higher.

Regardless of inspection regime, the probability of capture predictably decreases after the first six days as rats in the immediate area of a trap are removed. The element of diminishing returns thereby introduced into long-term (>5 days) trap lines is illustrated in Table 1, and was analysed in more detail from another, much more extensive database of both types by Watkins *et al.* (2010). However, re-invasion is inevitable, and is especially rapid in summer and autumn (King *et al.* 2011).

We suggest that pulsed trapping with pre-feeding can maximise capture rate per unit inspection effort by volunteers. On the other hand, we accept that some volunteers may be interested only in checking traps when convenient. Which strategy best suits a local trapping programme will depend on local decisions, but these results may inform the choice of method.

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REFERENCES

Cunningham, D.M. & Moors, P.J. (1983) A guide to the identification and collection of New Zealand rodents. New Zealand Wildlife Service, Wellington, New Zealand.

Innes, J., King, C.M., Bridgman, L., Fitzgerald, N., Arnold, G.C. & Cox, N. (2010) Effect of grazing on ship rat density in forest fragments of lowland Waikato, New Zealand. *New Zealand Journal of Ecology*, **34**, 227-232.

King, C. & Scurr, D. (2013) Efficacy of a community-led rat control programme at Lake Taupo, New Zealand. *Conservation Evidence*, **10**, 85-88.

King, C.M., Innes, J.G., Gleeson, D., Fitzgerald, N., Winstanley, T., O'Brien, B., Bridgman, L. & Cox, N. (2011) Reinvasion by ship rats (*Rattus rattus*) of forest fragments after eradication. *Biological Invasions*, **13**, 2391-2408.

Thomas, M.D., Morgan, D.R. & Maddigan, F. (2007) Accuracy of possum monitoring using wax tags. pp 1-50. Report to AHB by Pest Control Research, Lincoln.

Warburton, B., Poutu, N., Peters, D. & Waddington, P. (2008) Traps for killing stoats (Mustela erminea): improving welfare performance. *Animal Welfare*, **17**, 111-116.

Watkins, A.F., McWhirter, J.L. & King, C.M. (2010) Variable detectability in long-term population surveys of small mammals. *European Journal of Wildlife Management*, **56**, 261-274.

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