Effectiveness of diphacinone to control stoat populations

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Abstract

In the spring of 1996, work was undertaken to establish the effectiveness of the anticoagulant poison diphacinone to control stoat *(Mustela erminea)* populations. We attempted to determine whether stoats in the wild would take diphacinone delivered in eggs and, if they died as a result, what proportion of the stoat population was killed. Stoats were live trapped, and radio transmitter collars were attached. Livers from dead animals were analysed for the presence of diphacinone. Tracking tunnels were also used to indicate animal presence and activity.

Most of the stoats caught died before poison could be deployed. The reasons for this are discussed. Six of nine stoats recovered during the poisoning period showed measurable levels of diphacinone. Tracking tunnels and egg take show a marked decline in stoat activity during the poisoning period.

1. Introduction

In New Zealand beech forests *(Nothofagus* species), irregular but severe predation of breeding birds and chicks by stoats *(Mustela erminea)* has been implicated in the decline of several indigenous bird species, in particular mohua (O'Donnell 1996), kaka (Wilson et al. 1998), and kiwi (McLennan et al.1996). Methods to control stoats to prevent further decline in these species have been developed over the last two decades.

Methods for controlling stoats were reviewed and tested by King & Edgar (1977), King (1980, 1981), and King & McMillan (1982). The effectiveness of stoat trapping at preventing predation on mohua (yellowhead) populations was evaluated by O'Donnell et al. (1996) in a 40 ha forest block of the Eglinton Valley. This work showed that protecting mohua populations from severe predation using Fenn traps is feasible but very labour intensive.

To reduce the high cost and legal difficulties of trapping, various poisons, and methods of poisoning are now being investigated (Spurr 1996). The trials reported on in this paper are part of ongoing research that is aimed at protecting mohua and other indigenous bird species on a much wider scale than has been previously possible.

These trials were undertaken to establish how readily a stoat population could be controlled by the anticoagulant poison diphacinone.

2. Study area

The study area comprised two sites (Lake Sylvan and Millflat) on opposite sides of the Dart River at the head of the Lake Wakatipu, partly in the Mt. Aspiring National Park (168° 20'E, 44° 42-3'S). The steep-sided glacial valley with a large braided river is 3-5 km wide at this point. The two sites are 2.4 km apart at the nearest point. Both areas are reasonably flat, cut-over beech forest at the toe of the valley walls. Both border open, grazed grassland on the valley floor (Figure 1).

The sites are 1200-1400 m a.s.l. in forest dominated by red beech *(Nothofagus fusca)* with a canopy ranging from 20 to 30 m. There are significant stands of mountain beech *(Nothofagus solandri* var. *cliffortioides)* and silver beech *(N. menziesii)* where soils are thin over glaciated rock knobs. The understorey is open, with a little species variation in areas of beech regeneration subsequent to logging. The climate is wet (2000 mm annual rainfall at Lake Sylvan), but temperatures are moderated by the strong NW air flows of the Dart Valley (lowest canopy temperature winter 1996 was -6.8 °C).

3. Methods

3.1 DESIGN

We tested the effectiveness of a control operation using hens' eggs, injected with diphacinone, laid out around the perimeter of a tracking tunnel grid. The effect of the poisoning on the stoat population was to be measured in several ways. To establish that the dead stoats had taken diphacinone they were assayed for the poison's presence (National Chemical Residue Laboratory, Wallaceville Animal Research Centre, Ward Street, Upper Hutt New Zealand. Method: Pind V2HPLC). Necropsy looked for symptoms of anticoagulant poisoning like bleeding.

While the Lake Sylvan site was to be poisoned, Millflat was to be left as a non-treatment area. However, many of the radio-tagged stoats died of "natural" causes and few stoats were alive at the time of poisoning. No effective comparison between treatment and non-treatment areas was possible, so both areas were poisoned. Tracking tunnels were set out in each study area and checked weekly to give an additional measure of stoat activity. This, with egg take, gave a measure of the effect of poisoning on the wider stoat population.

3.2 LIVE TRAPPING

Stoats were live trapped in 34 'Elliott' and 40 'Edgar' traps, set out alternately, from mid September till mid December 1996. A treadle activated both designs of trap. The metal 'Elliott' traps, with a spring-loaded door, were modified by the attachment of a wooden nest box to increase stoat survival in the trap. The `Edgar' traps were a plastic version of the wooden live trap described by King & Edgar (1977). Stoats were ear tagged, fitted with radio transmitters, and released.

The two trapping lines were set out with traps at 200 m intervals. The Sylvan line comprised 42 live traps (8.2 km) and the Millflat line comprised 32 live traps (6.2 km) (Figure 1). This totalled 4550 trap nights. They were baited with a 2 cm cube of stewing steak, renewed every fourth day, and were checked daily.

3.3 RADIO TRACKING

Captured stoats were anaesthetised initially using Halothane, then ether from 30 October. Each animal was weighed, sexed, ear tagged, and fitted with a 9-12 g two stage radio-transmitter collar (Sirtrack, Landcare Research, Havelock North, New Zealand). Each animal was located at least once daily to determine if they were still in the area, and still alive. Moving stoats could be identified by their variable transmitter signal. If an animal was stationary for two days it was pin-pointed to see if it was dead. Considerable difficulty was experienced with `signal bounce' (inability to determine the direction of the signal) because of large and numerous rock bluffs. Consequently two stoats were unable to be located.

3.4 POISONING

Poison egg stations were a mixture of folded aluminium tunnels with entrance wire netting to prevent non-target species entry and eggs being removed for caching, and similar-sized wooden tunnels, with wooden floors and entrance protection of one wooden bar and two wires. Fifty-eight poison egg stations were put out at Mill flat, from November 5 till December 14. Thirty-eight stations were put out at Sylvan on November 13 till December 23.

The stations were placed at 100 m intervals around perimeters of the marked grids used for tracking tunnels at Lake Sylvan and Millflat (see Figure 1). Two eggs loaded with 3.75 mg diphacinone (a lethal dose for stoats - Spurr 1998) were placed in each tunnel. Egg take was recorded every second day.

3.5 TRACKING TUNNELS

Sixty tracking tunnels were set out on a 1000 m x 900 m marked grid at each study site. They were baited with 1 cm cubed of stewing steak. Tunnels were set out at 100 m spacing round the perimeter, with three rows across the interior. Most of the tracking tunnels were metal with a metal tray (King & Edgar 1977), but at Millflat one third of the tunnels (20) were plastic. The before-poisoning (Sylvan 5 Oct - 16 Nov; Millflat 17 Oct - 7 Nov) and after-poisoning (Sylvan 23 Nov - 20 Dec; Millflat 14 Nov - 12 Dec) tracking rates were compared using the Mann-Whitney U test.

4. Results

4.1 LIVE TRAPPING

Twenty-seven stoats were live trapped. Two were found dead in live traps and one escaped. Twenty-four animals had radio transmitters fitted. Two of those fitted with transmitters died overnight. Of the remaining twenty-two stoats with transmitters, twelve individuals were recaptured on 35 occasions (Table 1).The capture rate over the three month period was 0.57 stoats per 100 trap/nights.

Seventy six percent of the stoats live trapped were male. During the poisoning period only one of the eight females was known to be alive (F8), and she slipped her collar on December 4.

4.2 RADIO TRACKING

Twenty-four stoats were radio tagged. Seventeen bodies were recovered. Three stoats disappeared (left the area or the transmitter failed). Three stationary collars could not be recovered (the animals were assumed to be dead) and one animal slipped its collar.

There were 337 days of active transmission from 21 stoats (average of 16 days). Animal death rather than transmitter failure was the limiting factor. By December 18 no animal with an active transmitter was alive.

At Lake Sylvan, radio tracking indicated that stoats used the entire area bordered by Routeburn, Dart bush edge, and the Lake (1 km x 2 km, Figure 1). Occasionally, they spent a few days on the steep forest slopes to the west and on the western side of the lake (1 km x 2 km). One animal disappeared north of the lake for seven days. At Millflat some stoat ranges extended over 3 km of river flat forest.

No evidence was found that any collared stoats crossed the Dart River despite the core areas of study being only 2.4 km apart. Regular checks were made for missing animals on the alternative side of the river.

4.3 POISONING

In this trial 130 poison eggs were taken, many showing characteristic stoat sign of small canine hole entry leaving the eggshell largely intact (Flack & Lloyd 1978). At Sylvan there were two periods of poison egg take, 14 November to 1 December, and 10 - 20 December. A total of 47 eggs were taken (Figure 2). At Millflat the first eggs were taken on 9 November, and regular egg take started on 18 November and stopped on 5 December. Here 83 eggs were eaten (Figure 3).

The results of livers assayed for evidence of diphacinone are shown in Table 2. Seven stoat bodies were recovered during the period in which poison could have accounted for death. Necropsy showed evidence of internal bleeding in all seven stoats all of which were male. The last three stoats shown in Table 2, two females and a male, were kill trapped at Millflat at the end of the programme.

Four livers assayed contained no measurable diphacinone at a detection level of 0.05 mg/kg (Table 2). Stoat M16 died in a live trap 3.5 kilometres from the nearest poison which had been out five days, and may not have encountered poison. Stoat M3 had no body fat and had lost 20% of his body weight in 12 days. He had been exposed to poison eggs for a maximum of 7 days. This suggests he would not take eggs despite starvation. Stoats F9 and F10 were adult females and, though they were attracted to an egg in a kill trap four days after the poison eggs were removed, no measurable diphacinone was assayed. Stoat M19 was kill trapped a month after poisoned eggs were removed and had higher levels of diphacinone than found in two stoats that died earlier.

4.4 TRACKING TUNNEL

The tracking tunnel results show an average tracking rate of 48 tracks/week at Millflat in the three weeks prior to poisoning and 14.5 tracks/week in the four weeks after poisoning (Figure 4). At Sylvan an average of 19 tracks/week dropped to 4 tracks/week. Using the Mann-Whitney U test the before and after tracking rates were significantly different both at Millflat ($P = 0.05$) and at Sylvan ($P < 0.01$). The tracking tunnels at Millflat were continued as part of another study and no stoat tracks were recorded in December, January or February (Leticia McRitchie pers. comm.).

5. Discussion

Diphacinone poisoning

By 4 November, when poison eggs were first available, 68% (13 of 19) of the stoats collared to that date were dead or missing. There were four possibilities for this high death rate. We were capturing a population under extreme stress due to starvation; our actions were causing death (as a result of capture and recapture, anaesthetic and/or collars impeding hunting due to weight or shape); there was disease in the population; or a combination of these. Necropsy of those stoats dying earlier shows almost no fat deposits when compared with stoats recovered later (B. Lawrence unpublished data). This suggests that in spring the stoat population was starving, and that many of those stoats were going to die anyway.

However, this trial shows that stoats in the wild will take eggs containing diphacinone. Assay shows 5 of 6 the stoats known to have been present in the poisoning period and area had ingested diphacinone poison. Tracking tunnels show no mice, rats or hedgehogs present. There were few ferrets and only in limited areas. This limits the numbers and range of alternative `egg eaters' that could be responsible for the 130 eggs eaten.

Typically diphacinone, like other anticoagulants, takes several days to kill. It inhibits the production of vitamin `K', which is required to clot blood, and death results from haemorrhaging (Buckle 1994). Necropsies of five of the six stoats with measurable levels of diphacinone indicated internal bleeding consistent with anticoagulant poisoning. This suggests that diphacinone will kill stoats in the wild. The sixth (M19) was kill trapped one month after the poison eggs were removed. Several eggs were removed from two tunnels during the poisoning period and may have been cached, and could have been eaten later by this stoat.

The proportion of the stoat population which died due to poison cannot be determined with certainty. Considering all dead stoats recovered in the poison areas (M16, recovered 3.5 km away is excluded), 6 of 9 (67%) had ingested poison and 5 of those 6 (83%) probably died of poisoning. It may well be that the 3 stoats that were kill trapped had just moved into the area to replace the poisoned animals. Stoat M3 may have died of other causes before having the opportunity to take an egg. No collared stoat was alive at the end of the trial. This scenario suggests a large proportion of the stoat population is killed with diphacinone delivered in eggs.

Egg take and tracking tunnel results support this. The decline in egg take to zero suggests the egg-eating stoat population has either disappeared or become bait shy. Because of the delayed effects of an anticoagulant poison, the latter possibility is unlikely. The tracking tunnels were used as a secondary indicator for the death of stoats. There was a significant decline in the `tracking tunnel stoat footprint rate' for both Sylvan and Millflat ten days after poison was deployed. This is evidence of a population decline due to poisoning. It replicates correlations between diphacinone poison egg take and a decline in tracking of tunnels noted in the Sylvan area in the 1995-96 summer (B. Lawrence unpubl. report). Tracking tunnels at Millflat were continued until mid February as part of another project (Leticia McRitchie unpublished data). The absence of stoat tracks indicates that there was little or no stoat re-invasion during this time.

This direct evidence from collared stoats, and indirect evidence of egg take and tracking tunnels must be qualified.

It should be noted that the fall-off in both egg take and tracking rate at the end of November coincides with high numbers of bird fledglings emerging, providing alternative stoat food supply. Results from infra-red camera trials (which ran simultaneously with this project), and the three animals kill trapped at the end of the programme, suggest that there may be some stoats which will not enter a tracking tunnel or live trap or take poison eggs (B. Lawrence unpublished data). Two females who were kill trapped showed no measurable diphacinone less than a week after poisoned eggs were removed. This may indicate that traps can kill stoats that are unwilling to eat eggs, but are willing to check them out. This `wariness' may account for the under-representation of females in the live trapping results (18 males 8 females) and would be a problem if total stoat control is required. It may, however, be an indication that male stoats cover a much larger area than females and would therefore be more likely to encounter a trap or egg station.

Timing of experiment

If diphacinone is to be used to manage stoat irruptions in the future it will be a preventive control aimed at female stoats in late winter to early spring. The delay in death when using anticoagulant poisons means they have limited use during the breeding season of prey species (i.e. mohua), as the threat is immediate.

This trial was undertaken during the spring (following a stoat irruption) when past experience indicates stoat numbers are still high, food is not abundant and animals are readily trapped (King 1983, Alterio et al. 1999). While this was an advantage in increasing the chances of a good sample size in the present trial it does not determine whether a large enough proportion of the female stoat population can be poisoned in the late winter before a stoat irruption. At this time of the beech mast cycle, prey is believed to be plentiful and female stoats are difficult to catch (King 1983). A pre-irruption winter trial is necessary to determine if a sufficient proportion of the stoat population will take eggs at this time.

We must be cautious in drawing conclusions from these results. The numbers known to have been killed by poison constituted a very small sample, and contained no females. Egg take and tracking tunnel results (especially the zero footprints recorded from December-March at Millflat) are encouraging. But the proportion of the stoat population that will not enter tunnels, for eggs or meat, is unknown.

It is concluded that diphacinone had a major impact on the local stoat population, with the probability that the majority of the male population was effectively poisoned. Our sample is too small to draw any conclusions about the effect on females. Further research is needed to determine whether female stoats are too wary to take egg baits in seasons when prey is abundant.

6. Recommendations

It is recommended that a trial to test what proportion of the stoat population can be poisoned by diphacinone delivered in eggs in a pre-irruption winter/early spring be undertaken.

It is considered that the use of video cameras and scanners in the initial phase of this trial would provide conclusive evidence of variation in levels of egg take required to result in stoat death, and the average number of approaches required before egg take occurred.

7. Acknowledgements

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TABLE 1: LIVE TRAPPING RESULTS

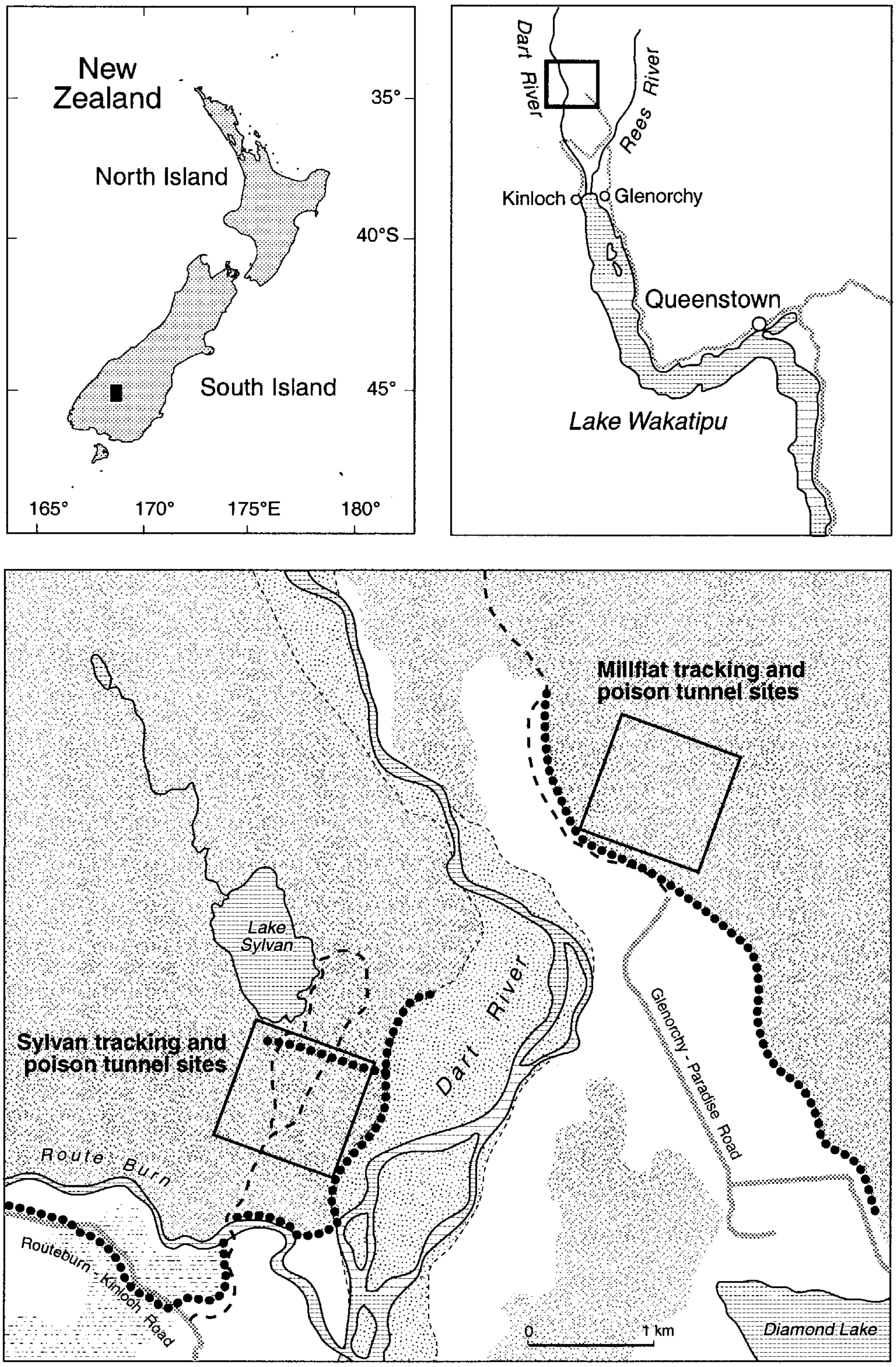
Period beginning	Sep 18	Sep 25	Oct 2	Oct 9	Oct 16	Oct 23	Oct 30	Nov 6	Nov 13	Nov 20	Nov 27	Dec 4
L. Sylvan	1	6	2	1	0	1	3*	0	2	0	1	0
Millflat	-	2	0	0	1	2	2	3	0	0	0	0
L. Sylvan recaptures	0	6	7	2	0	0	0	0	0	0	0	0
Millflat recaptures	-	0	8	3	1	4	2	2	0	0	0	0

*one of these escaped.

TABLE 2: RESULTS OF STOAT NECROPSY AND ASSAY OF LIVERS FOR DIPHACINONE

ANIMAL Reference number & sex	Time: poison deployment till death (days)	Distance of body from nearest poison	Evidence of internal bleeding	Diphacinone Liver assay results (mg/kg)
M16 Γ	5	3500m	no	0
M3 Γ	7	50m	no	0
M7 Γ	9	10m	yes	4.1
M15 Γ	15	700m	yes	2.5
M5 Γ	21	800m	yes	1.8
M18 Γ	28	20m	yes	3.9
M14 Γ	35	30m	yes	0.06
F9 E	40	3m*	no	0
F10 E	40	3m*	no	0
M19 Γ	70	**	no	3.2

* Kill trapped 4 days after poison removed **kill trapped 34 days after poison removed


New Zealand
North Island
South Island
35°
40°S
45°
165°
170°
175°E
180°
Dart River
Rees River
Kinloch
Glenorchy
Queenstown
Lake Wakatipu
Millflat tracking and poison tunnel sites
Lake Sylvan
Sylvan tracking and poison tunnel sites
Dart River
Route Burn
Routeburn - Kinloch Road
Glenorchy - Paradise Road
0
1 km
Diamond Lake

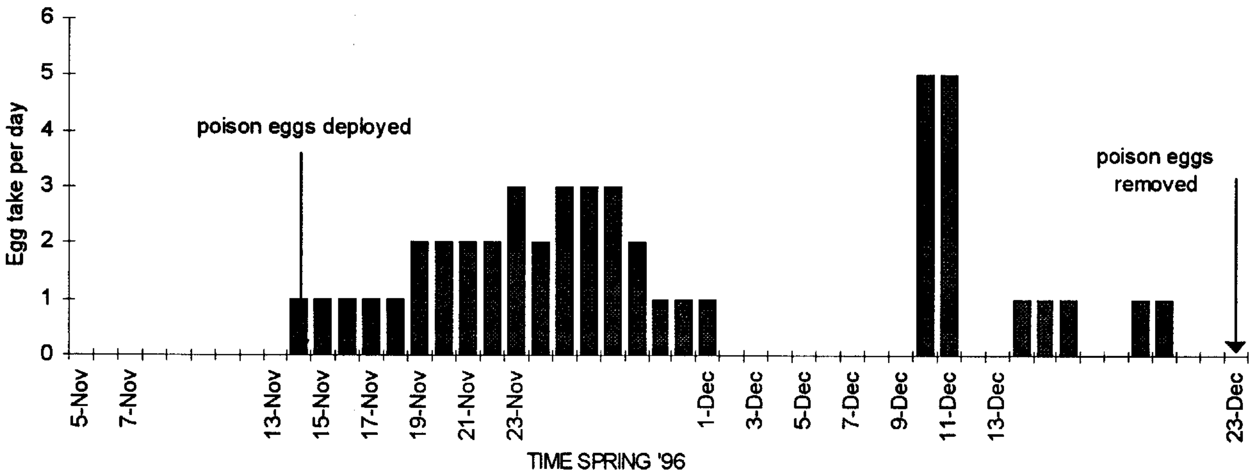


Figure 2: Poison egg take Lake Sylvan

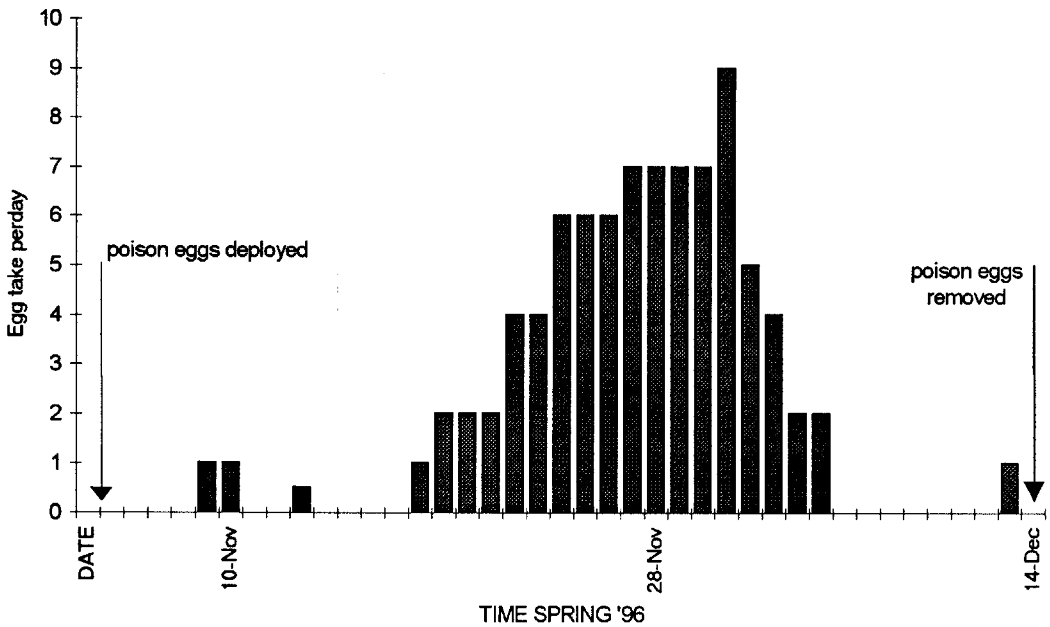


Figure 3: Poison egg take Mill flat

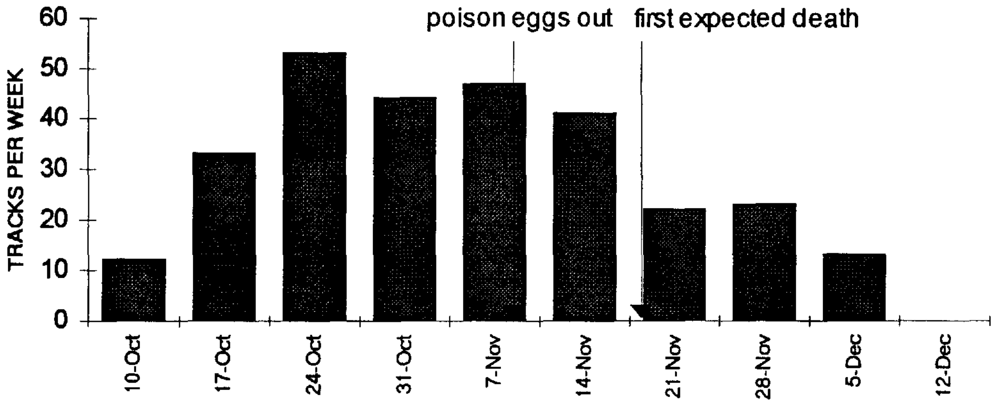


Figure 4: Mill flat tracking tunnel results

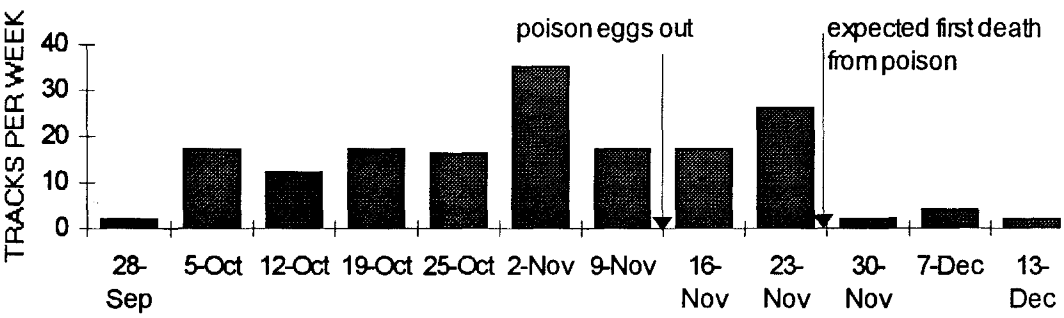


Figure 5: Sylvan tracking tunnel results