Movement, diet, and relative abundance of stoats in an alpine habitat

DOC SCIENCE INTERNAL SERIES 107

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff, or external contractors funded by DOC. It comprises progress reports and short communications that are generally peer-reviewed within DOC, but not always externally refereed. Fully refereed contract reports funded from the Conservation Services Levy (CSL) are also included.

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ISSN 1175-6519

ISBN 0-478-22394-3

This report was prepared for publication by DOC Science Publishing, Science & Research Unit; editing by Ian Mckenzie and layout by Ruth Munro. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

CONTENTS

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ABSTRACT

Almost all of the ecological research on stoats (*Mustela erminea*) in New Zealand has been confined to lowland forest habitat, with little or no emphasis on alpine regions. This study examined the movement, diet and abundance of stoats above the treeline in tussock grassland and in the adjacent beech-forest valleys in the Murchison Mountains, Fiordland, New Zealand, during two consecutive summers of high stoat numbers. Stoats in the valley-floor and alpine habitats seemed to be insular in their relationship to each other, and therefore, to protect takahe (*Porphyrio hochstetteri*) and other threatened alpine species from stoat predation, it will be necessary to trap both habitats. A prey switch to ground weta occurred as mice numbers declined, and not to birds, as is often expected or feared by conservation managers. In 1999/2000, the summer following a record *Chionochloa* mast, stoat abundance (as measured by catches per 100 trap-nights) in alpine habitat exceeded that in beech forest in three different valleys in the Murchison Mountains. However, during the summer of 2000/01, which followed a weak *Chionochloa* mast, stoats all but disappeared from alpine habitat, suggesting that there was a numerical response to the earlier *Chionochloa* mast. Concurrent stoat monitoring work by the Department of Conservation in the nearby Eglinton Valley showed a different pattern of stoat abundance over the same two years and thus should not be used by managers as an index of stoat numbers in the Murchison Mountains.

Keywords: stoats, *Mustela erminea,* home range, predator, radio tracking, seed mast, Murchison Mountains, Fiordland, New Zealand

Smith, D.; Jamieson, I.G. 2003: Movement, diet, and relative abundance of stoats in an alpine habitat. *DOC Science Internal Series 107*. Department of Conservation, Wellington. 16 p.

1. Introduction

During the 1880s, stoats (*Mustela erminea*) were introduced into New Zealand in an attempt to control rabbits (King 1983). Since then, stoats have been implicated in the decline of many native species (McLennan et al. 1996; Wilson et al. 1998). Almost all of the ecological research on stoats in New Zealand has been confined to lowland forest habitat, with little or no emphasis on alpine regions. The Department of Conservation (DOC) is investigating the feasibility of a stoat control programme in Fiordland to protect breeding takahe and other avian species that live above the treeline in the alpine/tussock zone. We set out to determine whether trapping in more accessible beech-forest valley floors would impact on stoats in the less accessible alpine zone.

New Zealand beech forests and snow tussock (*Chionochloa* spp.) exhibit heavy seed mast every 4–6 years (King 1983; Kelly et al. 1992). In the summer following a heavy beech mast, stoats reach extremely high densities relative to other years. However, no one has examined population fluctuations of stoats (and their main prey item mice) in the context of snow tussock seed masts. This study was conducted over two consecutive summers that followed two beech seed masts, and one heavy and one weak snow tussock seed mast, in the alpine area of Fiordland.

The Murchison Mountains (Fiordland National Park) is the only site where the endangered takahe (*Porphyrio hochstetteri*) is known to occur naturally. Stoats are the only species of mustelid thought to occur in high enough numbers in the Murchison Mountains to be a threat to takahe. During a recent study, predation on a sample of radio-tagged takahe was estimated to be between 2% and 10% (n = 51) (Maxwell 2001). Although this figure may seem small, population modelling of productivity data from other long-lived birds with low reproductive rates, such as albatross, have shown that even low levels of predation can have a significant impact on a population's viability (Croxall et al. 1990). Bird species such as brown kiwi (*Apteryx mantelli*), kaka (*Nestor meridionalis*), mohua (*Mohua ochrocephala*) and rock wrens (*Xenicus gilviventris*) are also known to be relatively abundant in the Murchison Mountains, and may also be at risk from stoat predation.

During what was predicted to be an outbreak year associated with a heavy beech mast, DOC commenced kill-trapping stoats in September 1999 in three valleys in the Murchison Mountains: Takahe Valley, Point Burn, and Mystery Burn. This research looks at the ecology of stoats in an untrapped valley of the Murchison Mountains known as the Ettrick Burn which, during the study, was 3 km away from the nearest kill-trapping which was taking place in Takahe Valley. The purpose of this research was to provide information that may be useful in designing and planning control operations to protect rare and endangered species in New Zealand's alpine habitats. In particular, the study examined stoats living in two adjacent habitats: beech-forest valley floors and alpine tussock habitat. The main aim was to determine whether individual stoats utilise both habitats, to assess whether trapping stoats in the more accessible beech-forest valley floor would help to control stoats in the less accessible alpine habitat. Related objectives were to:

- Determine which of the two habitats contains the most stoats, so that one habitat can potentially be targeted to reduce the stoat population in the Murchison Mountains
- Describe the diet of stoats in the Murchison Mountains, highlighting types of prey on which stoats are reliant, to provide insight into the mechanisms driving stoat population dynamics in the area
- Compare the relative abundance of stoats across different areas in the region to determine whether the eruptive dynamics of stoats inhabiting the Murchison Mountains is typical of the rest of Fiordland.

This report covers three subject areas: home range and habitat use, diet, and relative abundance. It is a summary of a University of Otago MSc thesis by D. Smith, completed in 2002.

2. Home range and habitat use of stoats

2.1 METHODS

This section contains a comparison between beech-forest valley floor habitat and alpine snow-tussock habitat. Two 3-km live-capture lines were set up in the Ettrick Burn. Each line consisted of 30 live traps spaced 100 m apart, with the first along the valley floor on the true left of the river 4.5 km upstream from Lake Te Anau. The second was 3 km to the north west of the first, and ran through the Dana Hut Basin and over its western ridge into the Mid Dana Basin. Live-capture lines were run for three to four nights every fortnight between December 2000 and March 2001. Live captured stoats were fitted with radio collars and released. Because of the difficulties of carrying out multiple live-trapping studies, tracking tunnels were used as a cost-effective replicate. All tracking tunnels were baited with red meat and set three nights a month, after which papers and bait were removed. Four lines of tracking tunnels were set in the Ettrick Burn valley floor, and another four on the ridges and faces of the Dana Peak site. Lines consisted of five tunnels spaced 100 m apart (spanning 400 m), with each line approximately 1 km apart. This design was replicated in both Chester Burn and Plateau Creek sites, located 12 km and 7 km to the west of the Ettrick Burn study site, respectively.

Minimum convex polygons were used to describe stoat home ranges, while kernel analysis was used to estimate core areas.

2.2 RESULTS

- More stoats (n = 13) were live-trapped between December and March in the valley floor than in the alpine habitat (n = 5); this result approached formal significance ($\chi^2 = 3.56$, d.f. = 1, $P = 0.0592$). More tracking tunnel lines were tracked in the valley floor habitat than in alpine habitat at all three sites ($F_{[3,10]}$ = 6.92, P = 0.008).

- A strong correlation (Pearsons Product Moment Correlation Coefficient) between the number of stoats known to be present through live-trapping/radio-tracking and the number of lines tracked at our main study site (r = 0.97), indicates that tracking tunnels were an effective replicate of our live-trapping/radio-tracking results.
- The mean size ± SE for fully revealed home ranges was 108.43 ± 26.52 ha (range = 16.76–251.93) (N = 9) for stoats found in the valley floor, and 57.27 ± 4.63 ha (range = 52.69–61.85) (N = 2) in the alpine habitat. Average home range size (habitats combined) was 49.88 ± 7.73 ha (range = 34.33–70.15) (N = 4) for females and 127.27 ± 30.42 ha (16.76–251.93) (N = 7) for males. The mean core area was 23.74 ± 3.59 ha (range = 16.96–33.07) for females and 68.35 ± 20.69 ha (range = 5.23–162.73) for males.
- During 3.5 months of fieldwork, no stoats were observed to move between the two habitats (Fig. 1).

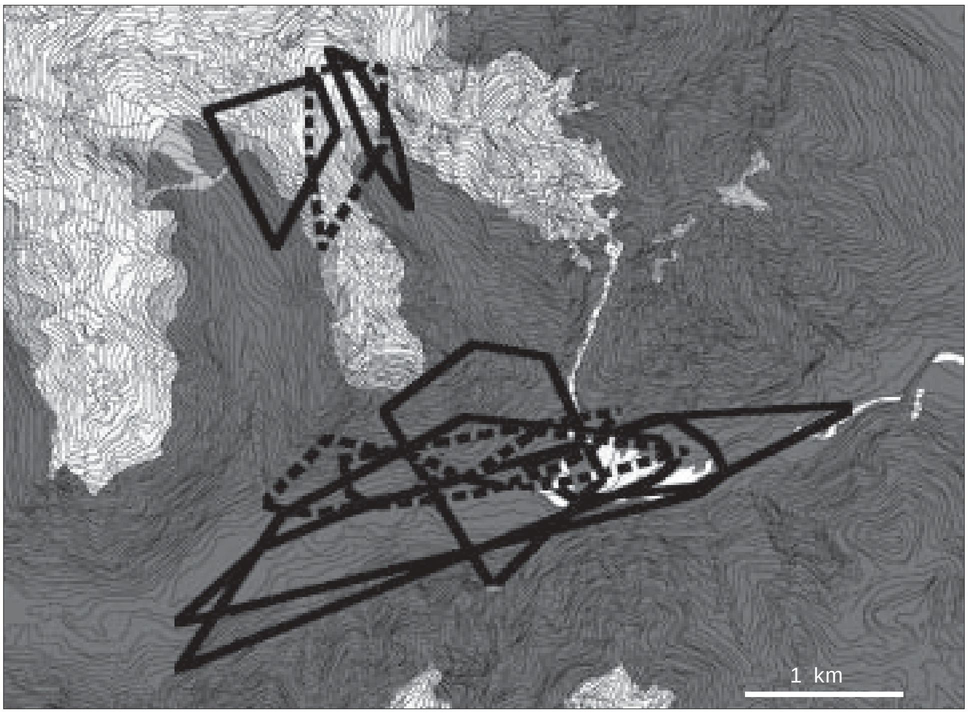


Figure 1. Minimum convex polygons around 100% of radio-locations collected on stoats inhabiting the Ettrick Burn study site during February 2001. Grey shading, beech forest habitat; white shading, snow tussock habitat; dashed lines, female home-ranges; solid lines, male home-ranges. Note, stoats inhabiting the snow tussock would not have encountered kill-traps set in the valley floor.

2.3 DISCUSSION

For the most effective control, conservation managers should ensure that the trap spacing they use falls within a stoat's core area. If trap spacing is based on 100% minimum convex polygons, traps may fall into areas that are rarely visited by a stoat. Analysis of the range cores suggests that a trap spacing of 200 m is satisfactory while 300 m might be more cost-effective, however a trap spacing of 400 m might exclude some of the smaller (female) range cores.

In 2000/01, lower numbers of stoats were resident above the tree line in *Chionochloa* habitat, at least during the summer months, but those found there and in the beech valley floors appear to be insular in their relationship to each other. Therefore, in order to protect takahe and other threatened alpine species from stoat predation, it will be necessary to trap both habitats.

3. Diet of stoats in an alpine/ beech-forest habitat

3.1 METHODS

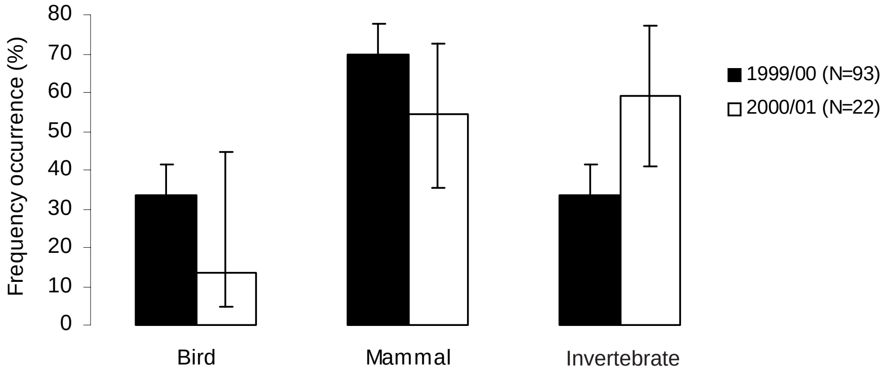
For the diet analysis, stoats were trapped between September 1999 and March 2001 at four sites in the Murchison Mountains: Mystery Burn, Takahe Valley, Point Burn, and the Glow Worm Caves.

Guard hairs found in stoat stomachs were used to identify mammals to genus level following the methods of Day (1966) and Brunner & Coman (1974). Feather remains were used to identify birds to order by examining the nodes and inter-nodal distances in the downy barbule region of the feather (Day 1966; Brom 1980). Exoskeleton remains were used to identify invertebrates to order, except for ground weta (*Hemiandrus* spp.) which were identified to the species level (P. Jones and A. Harris, pers. comm.).

3.2 RESULTS

- There was no significant difference between the four trapping sites in the proportion of each of three major prey categories (bird, mammal, invertebrate) in 1999/2000 ($\chi^2 = 4.009$, d.f. = 6, P = 0.75).
- There was a significant difference in prey type between years ($\chi^2 = 6.667$, d.f. = 2, P = 0.05). This difference appeared to be due to a significant increase in invertebrate prey items in 2000/01 (see Fig. 2, next page).
- Male and female stoats ate proportionally similar amounts of bird, mammal, and invertebrates ($\chi^2 = 0.348$, d.f. = 2, P = 0.90).
- Mammals occurred in 70% of stomachs in 1999/2000 (n = 93) and in 50% of stomachs in 2000/01 (n = 22). Mice and rats were the most commonly eaten mammalian species in both years. Significantly more mice were eaten than rats over both years ($\chi^2 = 16.96$, d.f. = 1, P = 0.001).
- Birds occurred in 33% of stomachs in the first year and 14% of stomachs in the second year. Passeriformes dominated, constituting 72% (N = 32) of stomachs with bird remains in them in 1999/2000, and 80% (N = 5) in 2000/01.

Figure 2. Change in diet of stoats over two summers following two consecutive beech masts.



- Invertebrates constituted 33% of prey items in stoat stomachs in 1999/2000 and 59% of prey items in 2000/01 (Fig. 2). The most commonly occurring invertebrate in stoat diet over both years was ground weta (*Hemiandrus* sp.), which constituted 89% (n = 28) of invertebrate prey items identified in 1999/2000 and 87% (n = 15) of those identified in 2000/01.
- During 1999/2000, small mammals were the most frequently occurring prey in beech forest, red tussock/beech forest ecotone and lake edge habitat, and birds were most frequent in alpine habitat, but differences were not statistically significant (χ^2 = 6.269, d.f. = 6, P = 0.50).

3.3 DISCUSSION

The results suggest that in the Murchison Mountains, a prey switch to ground weta occurred as mice numbers declined, and not to birds, as is often expected or feared by conservation managers.

Research in the nearby Eglinton Valley found the most commonly occurring item of prey to be bird (Murphy & Dowding 1995; King & Moody 1982b). In contrast, in the Murchison Mountains birds occurred less frequently than mammals and invertebrates.

The Murchison Mountains are home to many rare and endangered species such as the takahe, brown kiwi, and kaka. Although bird remains were not dominant prey items in stoat stomachs in the Murchison Mountains, this does not mean that stoats there are not impacting on threatened bird species in the area. The proportion of bird remains in stoat stomachs may just reflect the rate at which birds are encountered when compared to more common prey. As the number of stoats rise in the lag of peaks in abundant prey species (such as mice), their impact on rare species might be severe as has been shown in other parts of New Zealand (McLennan et al. 1996; Wilson et al. 1998).

As mice numbers rise after beech masts, the stoat population also increases and uses mice to maintain population growth. When mouse numbers crash, stoat numbers also decline, with the small number of remaining stoats in the Murchison Mountains apparently relying primarily on ground weta for their survival.

4. Relative abundance of stoats

4.1 METHODS

Kill-trap lines are often used as a relative index of stoat abundance by quantifying the number of stoats caught per unit of effort; this is most commonly done by calculating the number of stoats caught per 100 trap nights (C/100TN) (King et al. 1994). The use of C/100TN assumes that trapping success is directly related to abundance, particularly in a linear fashion (Brown et al. 1996).

Stoats used in this analysis were trapped during the summer months of 1999/2000 and 2000/01 at three sites in the Murchison Mountains: Mystery Burn, Takahe Valley, Point Burn. In order to compare between habitats, traps in the Murchison Mountains were identified as falling into one of three habitats: alpine (*Chionochloa* spp.), beech forest, and red tussock/beech forest ecotone. C/100TN were calculated for each of these three habitats at each site. C/100TN were then calculated for the Murchison Mountains as a whole for comparison with C/100TN from the Eglinton Valley (20 km to the north east of the Murchison Mountains), which were supplied by the Department of Conservation (DOC, unpubl. data).

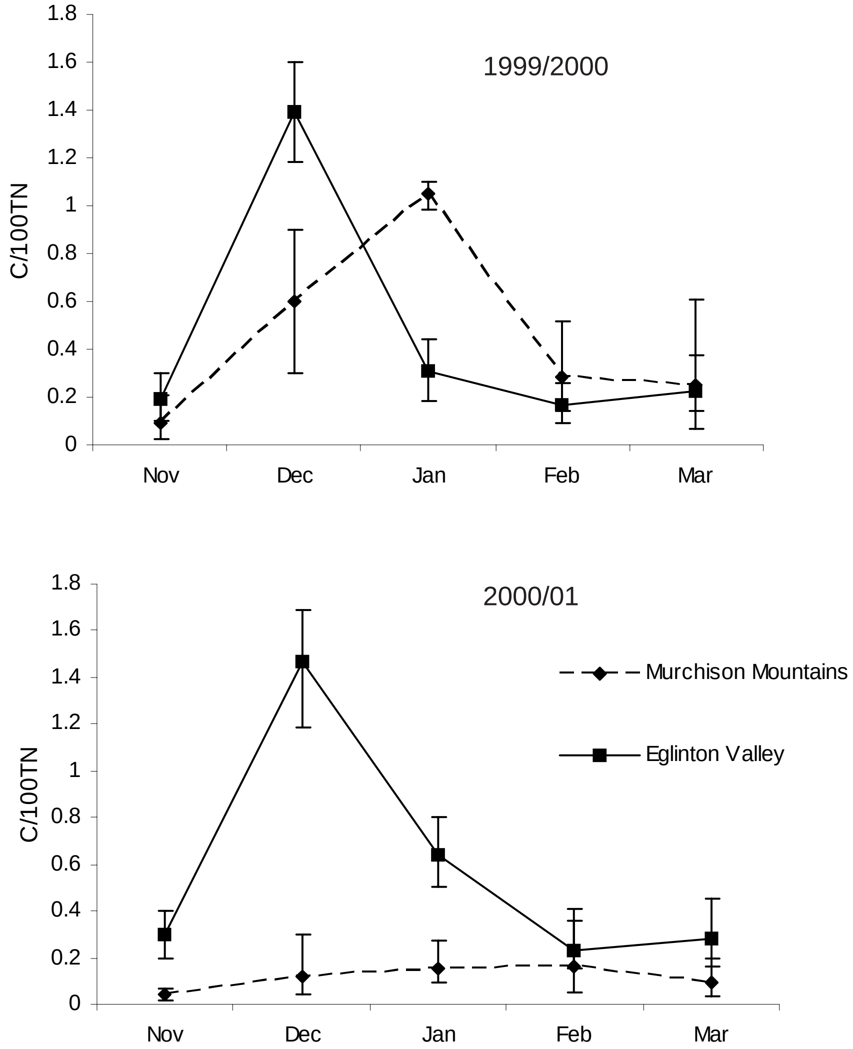
4.2 RESULTS

- No significant difference in C/100TN was detected between the three sites in the Murchison Mountains ($F_{[2,21]} = 0.45$, $P = 0.64$).
- C/100TN did vary significantly between the two summers ($F_{[1,21]} = 14.52$, $P = 0.001$), with 1999/2000 showing a peak in C/100TN during January, while in 2000/01 C/100TN remained low during all months.
- The highest peak in C/100TN in 1999/2000 was reached in the alpine habitat. In 2000/01, stoat captures in the alpine habitat all but disappeared, and stoats were most commonly caught in beech forest.
- The Eglinton Valley differed significantly from the Murchison Mountains with C/100TN peaking in December and showing peaks for both years ($F_{[1,4]} = 8.39$, $P = 0.04$) (Fig. 3).

4.3 DISCUSSION

In 1999/2000, the summer following a record *Chionochloa* mast, C/100TN in alpine habitat exceeded that in beech forest in three different valleys in the Murchison Mountains. However, during the summer of 2000/01, which followed a weak *Chionochloa* mast, stoats all but disappeared from alpine habitat, suggesting that there was a numerical response to the earlier *Chionochloa* mast.

Figure 3. Comparison of relative abundance of stoats within two different sites (Murchison Mountains and Eglinton Valley) in Fiordland National Park, during two consecutive mast years. Vertical bars indicate 95% binomial confidence intervals.



Stoat numbers in the Eglinton Valley peaked during both summers, following two consecutive heavy red beech masts, suggesting high reproductive success and juvenile dispersal during both years (Fig. 3).

During the summer of 1976/77, Lavers & Mills (1978) used stoat eruptive dynamics in the Eglinton and Hollyford Valleys to make inferences about takahe survival in the Murchison Mountains. They noted during this period that nine adult takahe went missing from a study area in the Murchison Mountains, and that this coincided with a summer of exceptionally high number of stoats in the Hollyford and Eglinton Valleys, where stoats were being caught at a rate of 7.5–9.0 C/100TN during January. In later years, Mills (1990) interpreted this period differently noting that takahe chick mortality was actually low during 1976, and that stoats were not a factor in the decline of takahe. The results of the present study suggest that such inferences about stoat density in the Murchison Mountains and its relationship to takahe survival should not be made using information from the Eglinton and Hollyford Valleys (Fig. 3).

5. General discussion and recommendations

5.1 ECOLOGY OF STOATS IN THE MURCHISON MOUNTAINS

The three aspects of stoat ecology that were looked at in this research (home range/habitat use, diet, and relative abundance) are all interrelated. The relative abundance of stoats at any particular site, or in any particular habitat, is related to the abundance of prey within that site or habitat. Therefore a stoat's ability to establish and retain a territory within a habitat depends on its ability to feed itself. Four main conclusions have been drawn from this research.

- Within their home range, stoats do not appear to move between beech forest and alpine habitat and therefore trapping in the easily accessed beech forest is unlikely to protect takahe or other native species that breed above tree line.
- Stoats are presumably more abundant in beech-forest habitat but numbers can be high in the alpine zone during summers of *Chionochloa* seed masts.
- After the peak in numbers of mice has begun to decline (following seed masts), stoats in the Murchison Mountains appear to switch to ground weta as their primary prey.
- Stoat relative abundance is not consistent between different habitats and sites or within and between years (across Fiordland), and therefore individual sites (e.g. Eglinton Valley) should not be used to make inferences about stoat density in other places (e.g. Murchison Mountains), unless consistent trends are revealed through replicated monitoring.

Nearly all stoats live-trapped in the Ettrick Burn were adults. Kill-trapping results suggest that if we had done the same study during the previous year, the opposite may have been true, i.e. a year earlier, juveniles would have constituted a large part of the sample, and therefore some immigration may have been observed between alpine habitat and the beech-forest valley floor. However, this research provides evidence that territories do not extend into both habitats and that trapping of stoats in one habitat cannot be relied upon to have a major impact on stoats in the other. The next phase of this research would be to track into the winter months any stoats inhabiting the alpine habitat, to see whether they remain resident or whether their movement patterns change.

Data from live-trapping and tracking tunnels across three sites in the Murchison Mountains indicated that for the summer of 2000/01 stoats were more abundant in the beech-forest valley floors than in the alpine habitat (predominantly *Chionochloa* spp.). However, in the previous summer, peaks in C/100TN at three sites were highest in alpine habitat. There were no related data from live-trapping or tracking tunnels in 1999/2000, and the relationship between stoat C/100TN and actual stoat abundance is poorly understood. Nevertheless, further research needs to consider the relationship between stoats, their prey, and the *Chionochloa* mast, with the purpose of determining whether stoats or mice respond numerically to the *Chionochloa* mast and whether in certain years they can reach higher densities in *Chionochloa* habitat than in neighbouring beech forest.

The importance of birds in the diet of stoats in the Murchison Mountains appeared to drop from 33% occurrence in stoat stomachs in the summer of 1999/2000, to 12% in the summer of 2000/01, although the 95% confidence interval for 2000/01 overlapped that of 1999/2000. However, an increase in predation upon birds after the crash in mouse population was not detected, and it seems feasible that a change in foraging behaviour associated with a change in primary prey, might affect the type of birds and their rate of encounter by stoats. This research tends to support King et al. (2001) in suggesting that the greatest impact upon birds will be when stoats are most abundant. Furthermore, future research needs to consider two potential trade-offs between stoats' main prey items in the Murchison Mountains (mice and ground weta):

- Which prey species is most energetically rewarding?
- Which of the two are easier for stoats to find, capture and handle?

Unfortunately, the distribution and abundance of ground weta in the Murchison Mountains is poorly understood.

5.2 WHAT CAN BE APPLIED TO TAKAHE?

Stoats are known to attack and kill adult takahe, but confirmed evidence is sporadic and the nature of the attacks poorly understood. The true impact of stoats on the viability of takahe population is unknown. This research made no attempt to measure or define the impact of stoats on takahe. Instead, it has focused on the ecology of stoats in the Murchison Mountains with the intention of providing information that might be useful in designing and planning control operations to protect rare and endangered species including takahe in alpine habitats in New Zealand. However, in doing so, it has provided information that may be useful for future research into the potential impacts of stoats on takahe.

First, the results suggest that stoats are not active in high numbers during October/November when adult takahe are sitting on nests and are potentially most vulnerable to predation. Instead, peaks in stoat activity seem to be in late summer and autumn. It is therefore suggested that closer monitoring of chick and adult takahe survival in late summer and autumn is necessary. Second, the higher abundance of stoats in the beech-forest valley floors, as observed during the summer of 2000/01, has implications for takahe and their chicks, which are known to move down into the beech-forest valley floors during the winter where they rely on *Hypolepis millefolium* as a primary food source. Third, conclusions drawn by Lavers & Mills (1978) and Mills (1990) about the impacts of stoats on takahe are considered questionable given that they drew their stoat abundance and takahe mortality figures from two different areas. Research into the relationship between stoats and takahe needs to include indices of stoat abundance at the site where the research is being carried out.

King et al. (2001) suggest that there is little evidence of prey-switching to birds by stoats when preferred prey becomes scarce. Rather, when stoats numbers rise in response to increases in their primary prey (mice), more birds are eaten as a result of the greater number of stoats, which eat birds at similar rates as they do when the stoat population is in lower numbers. This may be true for smaller birds such as Passeriformes, however at 3 kg, adult takahe are considerably larger than the average adult male (324 g) and female (207 g) stoat (King et al. 1994). Killing a large adult takahe must involve high-energy expenditure for a stoat, and although an adult takahe is of high-energy value, attacks are unlikely to always be successful. It therefore seems likely that stoats might avoid attacking adult takahe when mice and other smaller prey species are abundant. However, when preferred prey become scarce, chance encounters between hungry (male) stoats and adult takahe could lead to such attacks. Although this argument is somewhat speculative, its relevance is illustrated with the following comment. There are an estimated 130 adult takahe inhabiting the Murchison Mountains (Maxwell 2001), but this population would presumably disappear over night during a stoat plague year, if every stoat attacked every adult takahe it encountered.

6. Acknowledgements

This study would not have been possible without the support of Jane Maxwell, who originally promoted the idea of research into the movement and diet of stoats in the Murchison Mountains, and Dave Crouchley, whose countless years of experience in the Murchison Mountains were evident in the logistical support provided. We are also grateful to Elaine Murphy, Peter Dilks, Craig Gillies, Carolyn King, and Henrik Moller for providing equipment and important technical advice. In addition, Scott Davidson provided statistical advice, Oliver Buck assisted with the use of Arc View GIS, Peter Johns and Anthony Harris identified ground weta remains, and Murray Willans provided trap data from the Eglinton Valley.

Because of the difficult nature of the field work and the area, we feel obliged to mention all those who helped in the field. They were: Simon Torr, Nick Torr, Derm O'Neil, Ros Cole, Josh Kemp, Rachel Peach, Paul Johnson and Jazz, Nick Moyle, Kristen Charleton, Darren Scott, Jane Maxwell, Adam Reid, Abergail Rainey, Adrienne Markey, Rebekah Eyles, Jo Whitehead, Amy Whitehead, Brent Sinclair, Liz Scott, Willy Wakelin, Angus Small, and Jenny Christie.

This research was funded by: Department of Conservation's Stoat Technical Advisory Group, investigation no. 3411, Leslie Hutchins Conservation Foundation, Pacific Conservation and Development Trust, Department of Conservation—Southland Conservancy.

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