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Recovery of a Mohua (*Mohoua ochrocephala*) population following predator control in the Eglinton Valley, Fiordland, New Zealand

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ABSTRACT

Breeding Mohua (Yellowhead, *Mohoua ochrocephala*; *Passeriformes*) have been intensively monitored in the Eglinton Valley, Fiordland, since 1990. Birds were individually colour-banded and their territories mapped. Trapping and poisoning stoats (*Mustela erminea*) resulted in a large increase in Mohua numbers, but the population declined abruptly in winter 1996 following a period of unusually low temperatures. Details of the increase in numbers are presented and the reasons for the subsequent sharp population decline are discussed.

KEYWORDS: Mohua, Yellowhead, *Mohoua ochrocephala*, stoat, *Mustela erminea* predation, hole nesting.

INTRODUCTION

The Mohua (Yellowhead, *Mohoua ochrocephala*) is a small, insectivorous, forest passerine, endemic to the South Island of New Zealand. In the last century Mohua were among the most abundant and conspicuous forest birds in the South Island, but they have all but disappeared from 75% of their former range since the arrival of Europeans and the introduction of mammalian predators (Gaze 1985). Mohua are now regarded as endangered (O'Donnell 1993).

Monitoring has shown that Mohua suffer abrupt population declines during the stoat (*Mustela erminea*) irruptions that follow heavy beech (*Nothofagus sp.*) seeding (Elliott 1990, O'Donnell *et al.* 1996). Mohua are particularly vulnerable to stoats because they nest in holes, have long incubation and nestling periods, and breed in late spring, when stoat numbers are highest (Elliott 1990). The effect of stoat predation on the population is exacerbated by the fact that since only females incubate, most predation is on adult females (Elliott 1996a).

For most of the time, the impact of stoats on Mohua, their eggs and young is low (Elliott 1996b). However, high stoat numbers occur in beech forests in summers following heavy seeding of beech trees, an event which happens on average every 4-6 years (Wardle 1984). Insect, mouse (*Mus musculus*) and then stoat numbers irrupt with abundant food in the form of beech flowers and seed, (King 1983). In two Mohua populations studied during high seed years, a high proportion of eggs and nestlings were preyed upon, apparently by stoats, and about 50% of nesting females disappeared (Elliott & O'Donnell 1988, O'Donnell *et al.* 1996). Following such heavy predation there are often the same number of Mohua territories in an area but many are held by one or more males. It may take several years before enough young females are recruited to re-establish breeding pairs in all territories.

STUDY AREAS

The Eglinton Valley study area is located in Fiordland National Park (168°01'E, 44°58'S) and is a steep sided glaciated valley with a flat floor 0.5-1.0 km wide (Figure 1). The study area was divided arbitrarily into two areas of roughly 50 hectares, Knobs Flat and Deer Flat (Figure 1).

Mohua breeding territories were monitored along 4 km of valley floor forest. Most of this area comprises fluvial outwash fans at c.380 m a.s.l. (Figure 1). The forest is dominated by red and silver beech (*Nothofagus fusca*, *N. menziesii*). The forest composition ranges from pure stands of silver beech c.20 m tall along the forest margin to tall stands of red beech up to c.40 m tall further into the forest. Mountain beech (*N. solandri* var. *cliffortioides*) occurs occasionally in the canopy. Under the canopy the forest is generally open with few understorey plants and a moss ground cover. The most common understorey plants are mountain toatoa (*Phyllocladus alpinus*) and broadleaf (*Griselinia littoralis*).

METHODS

Mohua monitoring

The Mohua population at Knobs and Deer Flats in the Eglinton Valley has been intensively monitored annually since 1990; a smaller portion of Knobs Flat since 1984. From 1990 onwards, research on stoat control methods has also been carried out in the Valley. The presence or absence of predation on breeding Mohua was used as an indicator of the success of stoat control in the area and to this effect, a colour-banded population of Mohua has been maintained.

Each Mohua territory was allocated a number; as long as one identifiable member of a pair remained, the territory continued to have the same identifying number. If two unbanded birds were found where a banded and unbanded bird had previously been (possibly only one new bird) then a new pair and number were given to that territory.

Only in a few cases was it assumed that the same unbanded pair remained resident over several years. One-year old birds are much browner than older birds and have

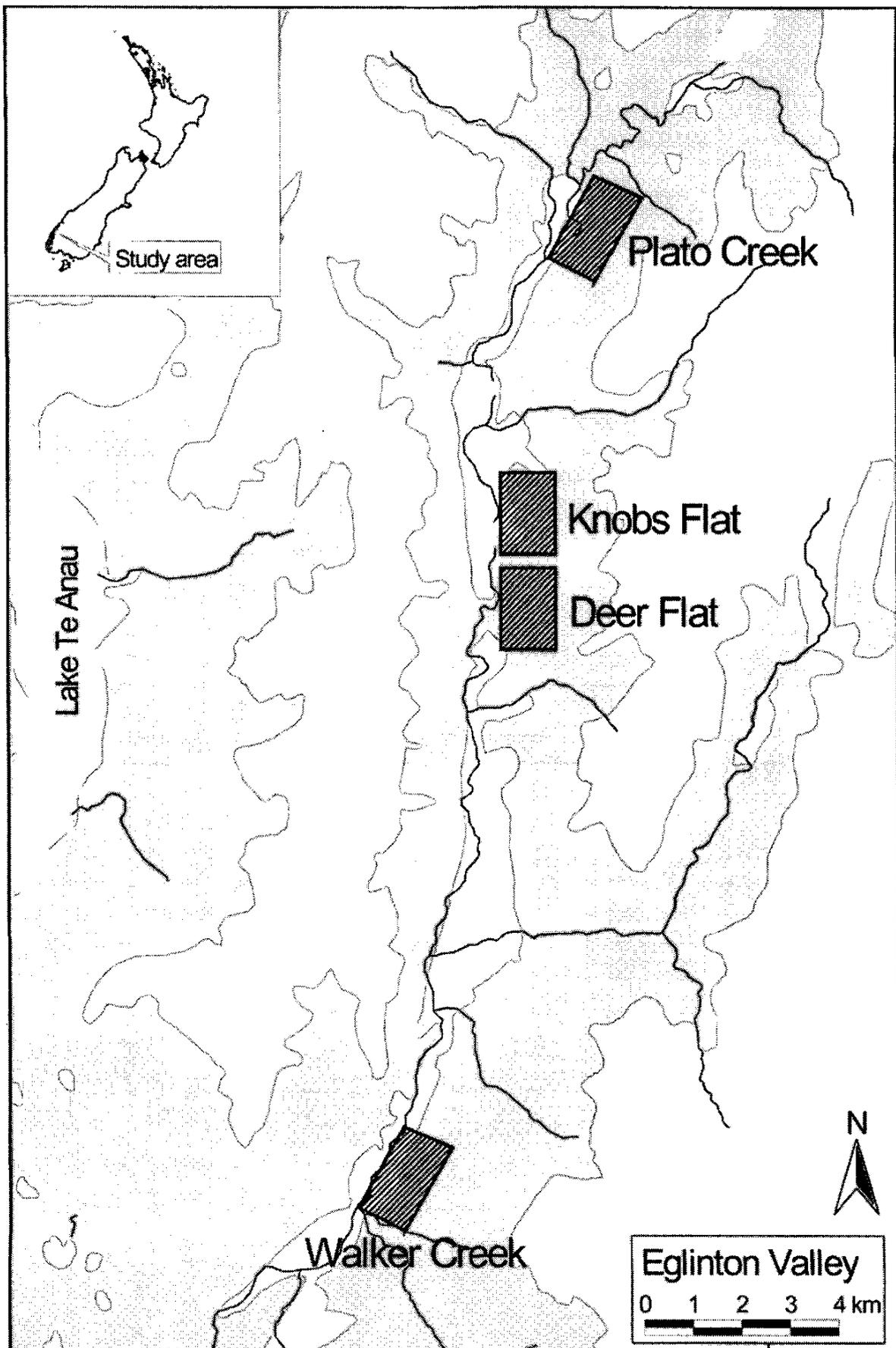


FIGURE 1 – Eglinton Valley, showing location of study areas.

TABLE 1 – Numbers of Mohua territories at Knobs/Deer Flat, 1990-1998.

* = stoat irruption year

Year	Male/female pairs	Male only territories	Total
1990/91*	19	0	19
1991/92	13	8	21
1992/93	21	2	23
1993/94	32	1	33
1994/95	39	0	39
1995/96*	39	0	39
1996/97	11	2	13
1997/98	14	0	14

TABLE 2 - Stoat control in the Eglinton Valley, 1990-1998.

* = Stoat irruption years.

Year	Fenn trapping	Poison eggs
1990/91*	Deer Flat	
1991/92	Deer Flat	
1992/93	Deer Flat	
1993/94	Deer Flat	
1994/95	Walker Creek	Plato Creek
1995/96*		Knobs/Deer Flat
1996/97		Walker Creek
1997/98	Length of valley	

immature song; they are easily identifiable. Male Mohua song develops over two or three years and both male and female become more yellow with age, so very old birds are readily apparent. Where an unbanded pair continued to develop increasingly yellow plumage, and remained uncharacteristically impossible to capture, they were assumed to be the same pair that occupied the territory the previous year.

Breeding Mohua have separate, discrete territories and are easy to map. The birds are most conspicuous during the period just before egg laying, from mid-October to mid-November, as both the male and female sing frequently. During the incubation period males are still vocal and conspicuous but females leave the nest to feed, usually only at 30-40 minute intervals. Most of the monitoring of Mohua was carried out in October and November each year.

Birds were caught for colour banding by erecting mist nets in the forest; territorial birds were attracted by playing recordings of Mohua song and distress calls. Most years we attempted to band any unbanded birds in our study area but some birds proved impossible to catch.

Stoat control

Research on stoat control was carried out in the Eglinton Valley from October 1990 onwards. Control techniques were tested at Deer Flat with Knobs Flat the non-treatment "control" area. Mohua breeding and survival was monitored in both areas. Stoat control trials varied from year to year (Dilks *et al.* 1996). Later trials evaluating the effectiveness of poison eggs were carried out elsewhere in the valley. The results of various stoat trapping trials and of monitoring breeding Mohua are summarised in Elliott 1996b, O'Donnell *et al.* 1996 and Dilks *et al.* 1996.

During the breeding seasons between 1990 and 1994, Fenn traps (a kill trap) with a variety of lures and trap layouts were tested for stoat control. In the following years (1995 - 1997) eggs injected with 1080 poison were tested.

Initially, all stoat trapping trials were carried out at Deer Flat but by November 1994 we found that so few stoats remained in this area that poison eggs were tested at Plato Creek 10 km up the valley where we expected to find more stoats (Figure 1). The following summer was a stoat irruption year and poison eggs were deployed in the entire Knobs/Deer Flat area. In 1996/97 more poison egg trials were carried out at Walker Creek, 15 km down valley, and in 1997/98 a new stoat control technique was tested: a line of Fenn traps at 200 m intervals along the whole length of the valley. Table 2 summarises the stoat control methods.

Possum (*Trichosurus vulpecula*) control was also undertaken in much of the valley and secondary poisoning of stoats feeding on possum carcasses may have contributed to the low stoat numbers in the central valley.

Winter temperatures

Weather data have been routinely collected at Knobs Flat by Works Civil Construction from a weather station in the centre of the study area. Weather data was collated over six winters, 1992-1997, to determine whether or not winter temperatures in 1996 had been unusually severe. To measure differences between the two study areas during the following winter (1997) two temperature recorders were placed in the forest; one in the centre of Deer Flat and the other at the back of Knobs Flat.

RESULTS

Mohua monitoring

Mohua territories usually contained only one breeding pair but in some years up to four non-breeding males were also present. These extra males usually foraged with the territorial pair and often helped feed fledglings. Non-breeding males were most often present in the years following stoat irruptions when many females had been killed. As young females were recruited, widowed males acquired new mates and the sex ratio approached 1:1 again.

The oldest Mohua remaining in the area was at least 16 years (it was originally banded as an adult), and up until winter 1996 there were 6 birds that were 12 or more years old.

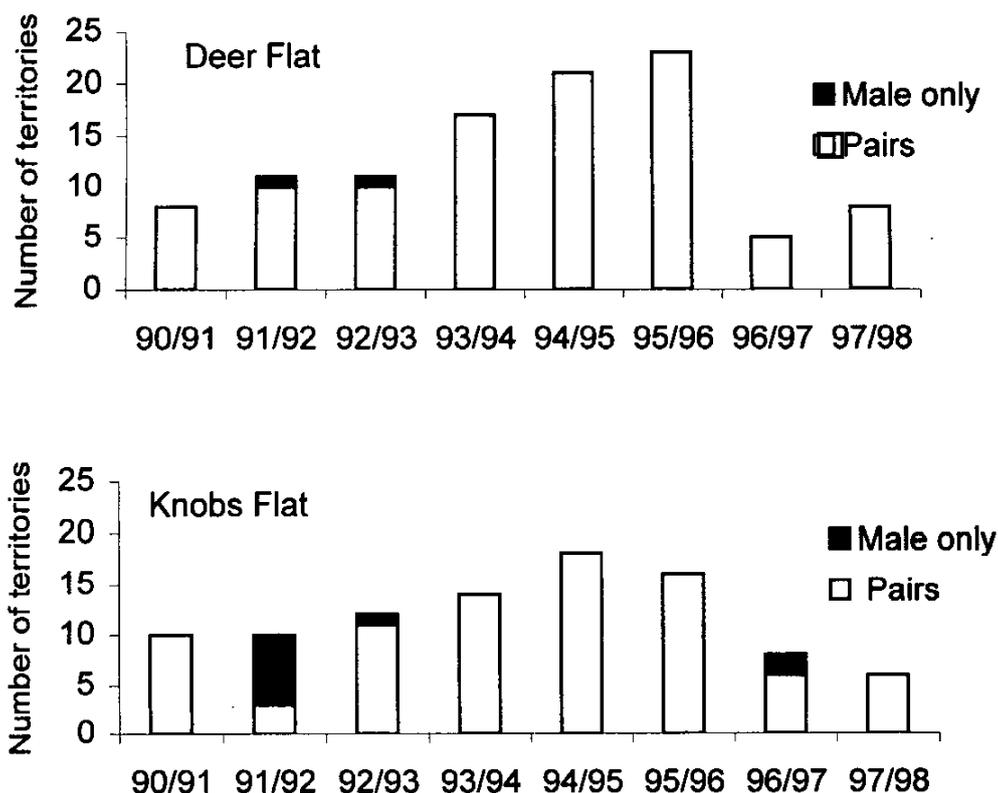


FIGURE 2 – Numbers of Mohua territories at Knobs Flat and Deer Flat, 1990-1998. Knobs Flat was the untrapped area during the 1990/91 stoat irruption where no stoat control was carried out.

With the start of stoat control in the Eglinton Valley in 1990, the number of Mohua in our study area showed a steady increase (Table 1, Figure 2). The effects of heavy predation on female Mohua at Knobs Flat during the stoat irruption in 1990/91 is demonstrated by the number of lone males in the 1991/92 census. It should also be noted that it took 3 years for all territory holding males to gain mates. The continual stoat control trials in the Eglinton Valley appeared to result in a much lower stoat population in the central valley. We had to move up or down the valley to find enough stoats for further trials; by removing stoats from adjacent areas we also increased the protection of the study area Mohua.

There was no known predation on adult Mohua during the 1995/96 irruption year; an attempt to trap stoats live for radio tracking in that year resulted in only one adult stoat being caught. The summer of 1995/96 was unusual in that Mohua raised only single broods (usually most raised two broods) so that breeding was over before the usual January predation peak. Almost all of the breeding pairs were alive at the end of summer.

In October 1996 territory mapping revealed there had been a major decline in the Mohua population of the study area. Over that winter most of the birds from 28 territories vanished and there had been mate changes probably due to the death of an original pair member in several of the remaining pairs. At least 53 of 80 (66%) territorial birds died. This level of mortality was unprecedented and followed a cold spell in July 1996.

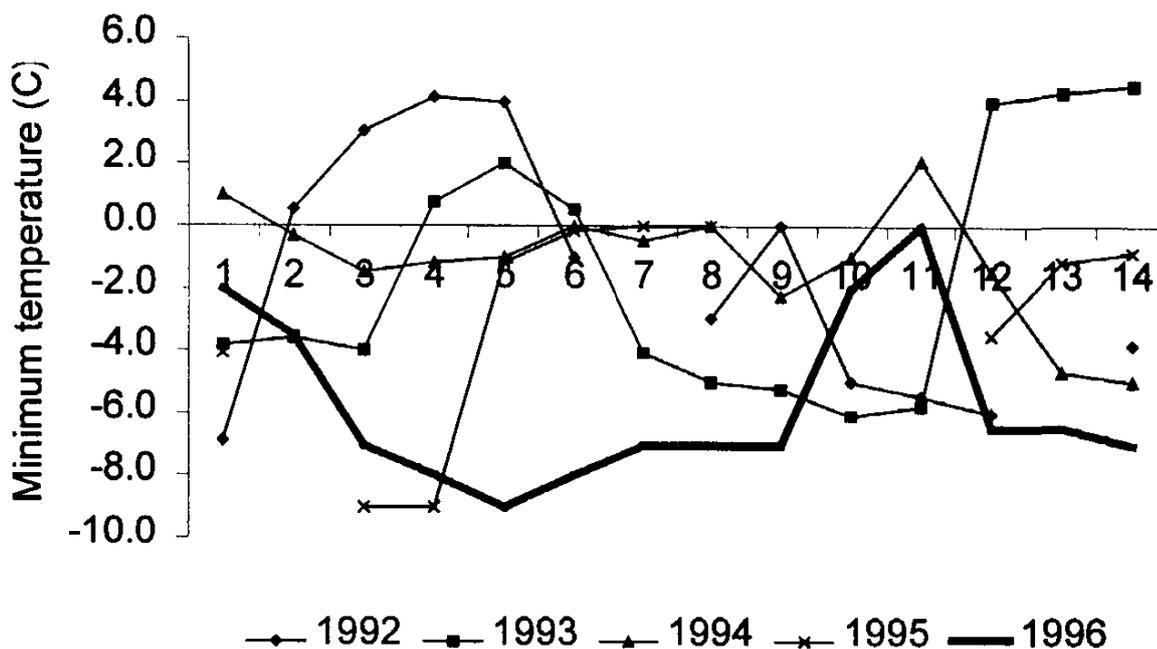


FIGURE 3 - Minimum temperatures at Knobs Flat during 1-15th July 1992-1996 (°C).

Deer Flat lost almost all of its Mohua (18 of 25 pairs, a 72% loss) with only a few pairs remaining at either end. Knobs Flat too had a large reduction in number of pairs (29% loss) but it was not as dramatic. Most of the pairs that survived had territories that were adjacent to the steep valley sides and these birds may have been able to move up to areas that experienced less extreme temperatures.

The Mohua population in the Eglinton increased slowly from a low of 11 female territories in 1996 to 14 in 1997.

Stoat trapping

Stoat live-trapping and radio tracking in 1996 confirmed earlier indications that stoat numbers remained low in the central Eglinton Valley. With similar trapping effort we caught only two stoats along 16 km of valley near Knobs/Deer Flat compared with 15 animals caught along four km of valley floor at Walker Creek.

Winter temperatures

In early July 1996 there was an unusually cold period: over a 7-day period the minimum temperature was between -7°C and -9°C (Figure 3). Data collected in similar habitat in the Dart Valley over the same period showed that even at 15 metres above ground in the forest canopy, the temperature rarely rose above 0°C (B. Lawrence pers. comm.). It is likely that the Eglinton Valley forests experienced similarly cold temperatures.

The loggers placed in the forest during the following winter logged temperatures at 3-hour intervals during June, July August 1997. These showed that during cold periods, Deer Flat was usually one degree colder than Knobs Flat.

DISCUSSION

Sharp declines in female Mohua numbers after stoat irruptions suggest that stoat predation has a major effect on Mohua numbers and population structure. A study of Mohua at Knobs Flat in the Eglinton between 1984 and 1988 by Elliott (1990, 1996b) found that in 1987/88 six of 12 females in his study area vanished. This was the summer following a beech mast with very high stoat numbers. During the next stoat population irruption (1990/91) seven of ten females were lost from an unprotected population in the same area (O'Donnell *et al.* 1996). The presence of male nest helpers appears to be a direct result of the sex specific nature of stoat predation. Once the predation pressure is removed the sex ratio eventually returns to 1:1.

In the absence of stoat predation, pairs were stable and territorial birds long-lived (Elliott 1996b, present study). There were few confirmed losses of both members of a pair between seasons; losses occurred only between 1994 and 1995, and between 1995 and 1996. Between the spring census of 1994 and 1995, seven pairs vanished from the study area. However, five of these were from an area of short, open, beech forest with sparse leaf litter, which was probably inferior habitat (Elliott 1992).

Most were young birds that had not previously held territories and had squeezed in where the density of territorial birds was lowest. Increased competition pressure may have caused the subsequent loss of these birds.

The sharp decrease in numbers recorded in spring 1996 is almost certainly attributable to the unusually severe winter that year. Birds may have died of hypothermia and/or starvation because fewer invertebrates were available in the cold weather. The lower temperatures coupled with greater distance to warmer valley side forests may have been responsible for higher mortality at Deer Flat. Transect monitoring suggested that other Mohua populations in Otago and Southland also appeared to have suffered major declines. In the Blue Mountains numbers appear to have fallen 50% (M. Foord pers. comm.), while in Rowallan Forest there appeared to be a reduction in numbers by 20-30% (W. Baxter pers. comm.). Elsewhere in Southland widespread bird mortality was recorded in early July. Large numbers of Black-billed Gulls (*Larus bulleri*) and Spur-winged Plover (*Vanellus miles*) were found dead and many native bird species vanished from forest areas of Southland (Wood 1998).

Loss of both birds of a pair was rarely recorded. Predation by stoats usually resulted in the loss of large numbers of females and many territories being held by males alone. A population viability analysis by Elliott (1996a) concluded that populations, such as that of the Eglinton which raise two broods per year, had good prospects for continued survival since they are able to recruit enough birds between stoat irruptions to maintain themselves. However, data for this model were collected during years with much lower winter Mohua mortality and did not take into account catastrophic events such as the winter of 1996.

Although stoat trapping provides effective protection for breeding Mohua, it has been assumed that its effect is only temporary since additional stoats will move

in between seasons. However, repeated stoat control every summer seems to have lowered the stoat population overall. This may be sufficient to prevent irruptions in stoat numbers following beech mast years and the usual high predation on female Mohua; juvenile stoats migrating into the area will probably arrive after the vulnerable phase of Mohua nesting is over.

The data presented indicate that Mohua populations will display a rapid increase in both numbers and density following stoat control, but rare climatic events can nonetheless decimate a population. Before the forest structure was altered by introduced browsing mammals, Mohua would have had a more diverse food supply (they also feed on fruit), and so historically may have been less vulnerable to an abrupt decline in the abundance of invertebrates.

Implementation of predator control before the 1996 population crash occurred may have been fortuitous. The Eglinton population had had time to recover from the effects of stoat predation. Had the population been subjected to heavy predation the previous summer, it might well have been wiped out by the severe winter of 1996.

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