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Call count responses of North Island brown kiwi to different levels of predator control in Northland, New Zealand

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Abstract

North Island brown kiwi have been monitored by a standard call count index at 23 stations in Northland, New Zealand annually since 1995. An attempt is made here to determine whether there are any trends in call counts that relate to predator control and advocacy in and around each listening station. Both predator and advocacy effort were rated on a 0–3 scale at each of 23 listening stations, and kiwi calling rates analysed on a generalised linear model. An analysis of variance (ANOVA) indicated a positive response of call counts to predator control. There was a weaker relationship with advocacy, but because predator control and advocacy are correlated, it was not possible to separate their effects. Ground moisture levels had a significant positive effect on calls, while wind and rain had negative effects. Overall, the analysis suggested that this kind of management is benefitting kiwi in Northland.

Keywords: Kiwi; *Apteryx mantelli*; Calling responses; Monitoring; Predator control; Advocacy

1. Introduction

North Island brown kiwi *Apteryx mantelli* have declined in numbers and range in Northland and elsewhere since the 1970s (Miller and Pierce, 1995). Research during the 1990s determined that predators (particularly mustelids *Mustela* spp., dogs *Canis familiaris* and cats *Felis catus*) were responsible for most of the observed decline in Northland (Pierce and Sporle, 1997; H.A. Robertson, personal communication). Management was begun in an attempt to stem the decline of kiwi and recover populations. Management comprised a variety of mainly experimental approaches including intensive predator control, pulsed predator control, and general and site-specific advocacy in which dog control was a focus.

One of the problems of recovering kiwi is how to measure their responses to different levels of predator control and advocacy. Kiwi are cryptic birds and the most reliable monitoring regimes currently involve radio tracking and/or using trained dogs to sample age structure (Robertson et al., 1999). These approaches have been instructive in determining outcomes for the intensive management at Trounson Kauri Park (Herbert, 2000) and the experimental management of study areas in the Purua area (Robertson et al., 1999). The cost of this sort of detailed monitoring, however, precludes more widespread use.

A complementary approach has been to establish listening stations. In the mid 1990s a network of call count stations was established nationally in order to determine trends in populations over time and to evaluate responses of kiwi to different management regimes (McLennan, 1992). In Northland 23 stations were established in four geographic areas (Appendix), and were designed to enable a detection of a minimum change of 25% in call counts over a 5-year span. Additional stations have since been added to this network.

Whilst this approach met the first objective of monitoring (detect trends in populations over time), it did not meet the second objective (measure response to specific management regimes). This was because most management of kiwi in Northland occurred on a small scale. For instance Trounson and Katui are 8 km apart in western Northland, but Trounson receives intensive predator control and advocacy, whereas Katui has

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no predator control and low advocacy. Clearly a station-based method was needed in order to assess kiwi responses to management in Northland. This paper evaluates outcomes for station-specific management.

2. Methods

2.1. Listening stations

Since 1995, 23 listening stations have been monitored annually in May–June, the recommended period for listening for North Island brown kiwi (McLennan, 1992). These stations are clustered in four areas:

Northern: five stations in or on the edge of extensive forest in the Herekino–Raetea–Puketi Forests area.
Eastern: six stations in forest remnants and extensive exotic forestry in the Bay of Islands area spanning Purerua Peninsula–Waitangi–Russell Peninsula.
Western: five stations in extensive forest (two in Waipoua) or forest remnants (Katui, Trounson and Paerata).
Southern: seven stations within 30 km of Whangarei, all north-west to north-east of the city and involving forest remnants including two also with exotic forests.

2.2. Listening methods

Listening took place for the first 2 h of darkness on each of four nights in the dark phase of the moon in mid May–June each year. Listeners avoided wet and especially windy nights that might have reduced the detectability of calls. The same listening station was used each year. Listeners completed standard Kiwi Call Scheme cards or photocopies of them. The same person listened at the same station from year to year (Appendix) unless it was absolutely necessary to change personnel. This minimised observer error within each station over time. For each hour of listening on each night listeners recorded an index for the levels of a number of environmental variables—wind, rain, temperature, cloud, ground condition (moisture), noise, and moon, according to the national standard kiwi listening protocol. Descriptions of the indices are given in Table 1.

Table 1
Physical variables collected during each hour of kiwi listening

Wind	Calm, light, moderate, strong (and direction)
Rain	Nil, light, moderate
Temperature	Cold, mild, warm
Cloud cover	Clear, partly cloudy, overcast
Ground condition (moisture)	Dry, damp, wet
Noise	None, slight, moderate
Moonlight	Light, dark, black

2.3. Station management rating

Because mammalian predators (particularly mustelids, cats and dogs) are known to be the prime problem for kiwi (McLennan et al., 1996), we have rated only those predator control regimes that impact directly or indirectly on predators. The rating system provides a coarse measure of effort in predator control and advocacy, firstly because actual operational monitoring (effect on predators) was generally not measured, and secondly, because the effectiveness of predator control and advocacy probably increased during the study period through refinements. A four-point scale was used to rate the level of effort of both predator control and advocacy (Table 2). The rating score was applied irrespective of the size of the pest management and advocacy unit. In nearly all cases the listening area was contained well within each management unit.

2.4. Analysis technique

2.4.1. Estimating the trend

The kiwi calls over time were analysed using a generalised linear model fitted to all the data from the kiwi call programme in Northland, including some stations that did not have complete data for the period. The response variable was the total count for one night. For most stations there were four nights in each of 6 years, that is 24 points. An offset variable allowed for the few occasions when the daily observation period differed from 120 min. Thus the rate of calls each night effectively became the response variable. Kiwi are known to begin calling in their first 6 months of life, but possibly do not reach average adult calling rates until they are territorial at about 3 years of age (R. Colbourne, H. Robertson, personal communication).

The primary explanatory variable in the model was a linear trend over the years fitted for each station, and other explanatory variables allowed for possible effects of temporary environmental factors such as wind, rain, ground moisture and moonlight. All the potential explanatory variables in the model were entered in an initial model, then selected in a stepwise manner.

The counts were linked to the explanatory variables by the log function, implying that an additive change in any explanatory variable multiplied the mean count by a constant. Estimates were formed assuming the counts had variance proportional to their underlying mean value (S-PLUS 2000 Guide to Statistics).

This model provided an estimate for each station of any linear trend in rates of calling over the years, adjusted for short-term environmental effects.

2.4.2. Comparing the trend levels with level of management

The trend levels were plotted against the levels of predator control rating for the 23 stations with complete

Table 2
Rating system for predator control and kiwi advocacy at Northland listening stations

Predator control rating		
Score	Control	Examples
0	None	Possum control (if any) by cyanide; no predator control.
1	Little	Local predator trapping or local and/or one off use of talon.
2	Medium	Widespread trapping or intermittent talon/1080.
3	High	Intensive predator trapping over listening area.
Advocacy rating		
Score	Advocacy	Examples
0	None	Media coverage only.
1	Little	One off visits to locals, schools, marae, etc.
2	Medium	Repeated visits to locals etc
3	High	Medium rating for advocacy of predator control plus high involvement of community in kiwi projects.

call data for the period 1995–2000, and with ratings for control. ANOVAs compared the mean level of trend in rates of kiwi calls between groups of stations based on levels of management and on the four areas.

3. Results

3.1. Comparing the trend levels with level of management

For each of the 23 stations, the trend levels, estimated as percentage change in kiwi call rate per year, are plotted against predator control rating in Fig. 1. The graph indicates an association, which is confirmed at the 5% significance level by an ANOVA when different predator control levels were treated as unordered factors ($F_{3,19} = 3.177$, $P = 0.048$). The significance is much higher when the predator control is treated as a linear factor, implicitly assuming that the levels of the factor are equally spaced ($F_{3,19} = 7.685$, $P = 0.011$).

There is also information about advocacy ratings for these stations. However, these did not show as a significant relationship with change in kiwi call when taken as unordered factors ($F_{3,19} = 1.946$, $P = 0.156$). Advocacy rating was significant if taken as a linear factor on its own, but once predator control effects were taken into account, did not provide any significant additional information about the change in call rates. Predator control and advocacy at these stations is highly correlated, as seen in the Appendix, meaning that the data were not well set up to differentiate the impact of the two elements of management.

However, area provided a possible alternative explanation of much of the variation in the data ($F_{3,19} = 7.685$, $P = 0.011$). In a model including both area and predator control, once the effects of area were taken into account, there remained some evidence, albeit weak, of an effect of predator control as a linear factor ($F_{1,18} = 3.449$, $P = 0.080$).

3.2. Effects of environmental conditions

The modelling also provided estimates of the impact of the recorded environmental variables (Table 1). Three of the variables—wind, rain and ground condition (moisture)—contributed to the model and had significant effects on the levels of the kiwi calls in the data. Ground moisture had a positive effect—with each increase in the index leading to an average 12.7% increase in calls (95% confidence interval 7.0–18.7%). Not surprisingly given their impact on ability to hear, wind and rain had negative effects on calls as their levels increased. Wind gave a 6.0% decrease (1.7–10.1%) and rain gave a 12.2% decrease (3.5–20.2%) for each increase in the index. Temperature, cloud, noise and moonlight appeared not to have a significant impact on call rates according to this model, once the other factors were taken into account.

4. Discussion

A relationship between the level of predator control and the rate of change of kiwi call counts is indicated by these data. The unbalanced nature of the data—with unequal numbers of stations at different levels of treatments—makes it difficult to clearly distinguish between the impact of the various factors, yet there is some evidence of an impact of predator control even after any effect of area is taken into account.

It must be noted that ours is strictly an observational study. It is a retrospective analysis of a 'sample of convenience'. The data gathering was designed for a national monitoring programme—rather than for station-by-station analysis. In particular, there was no random allocation of treatments to stations. There is a need to be cautious about concluding a causal relationship from these data alone.

However, the extensive network of stations, together with the consistency and regularity of recording kiwi

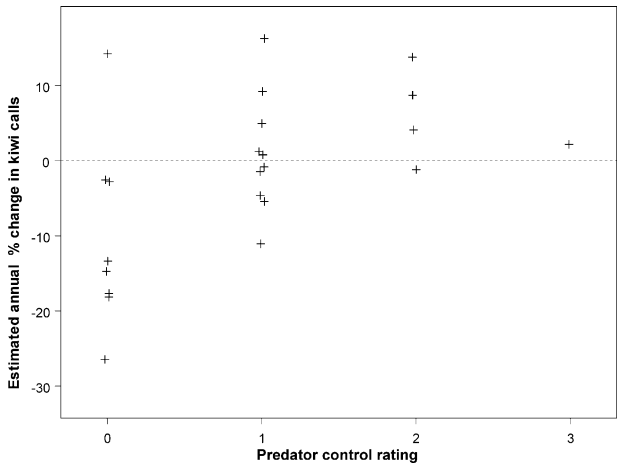

Fig. 1. Estimated annual percentage change in kiwi calls in Northland, 1995–2000 versus predator control rating at 23 stations.

calls and associated information, allow confidence in the patterns which emerged. The relationship shows almost exactly the patterns expected when management is having an impact. Provided there is no other mechanism evident that could lead to this relationship (e.g. allocation of treatment to stations that could be expected to have positive trends in any case) our data support predator control as a mechanism for increasing kiwi calls. The presumption is that changes in kiwi call rates reflect changes in kiwi populations.

The results also depend on the validity of the model fitted to the data. In particular, the trend over time was not always a simple linear one. However, there was no consistent pattern evident between stations in any non-linearity. The linear trend estimated should give a reasonable first approximation to any trend over time.

It is not possible from these data to separate relative contributions from predator control and advocacy. For these data and model, predator controls show a stronger relationship with trends in call rates. It may never be possible to separate the effects as any predator control will also have good local advocacy. In Northland advocacy is a prerequisite for kiwi recovery because of potentially high dog predation of kiwi—(Pierce and Sporle, 1997). Current intensive studies show that control of small predators, particularly mustelids and cats is also needed because of high chick loss to predators, and that intensive predator control can bring about high juvenile survival (Robertson et al., 1999; Herbert, 2000). The finding that call counts at Trounson (the only station that scored 3 for predator control) have not responded more positively over the past 4 years of management is initially surprising. However, Trounson had high call counts in the first instance and high densities of birds are present at the site, suggesting that it might be close to carrying capacity. Although several young have been recruited at the Park, others have dispersed up to 20 km from the reserve to neighbouring Waipoua Forest (Herbert, 2000).

While this analysis shows that it is possible to discern patterns of relationship between different levels of predator control and average trends in kiwi call rates, the estimate of trend at any particular station is subject to substantial error. The ANOVA provides an estimate of 9.7% for the standard deviation of the trend within a group with the same level of predator control, which suggests a 95% confidence interval of about $\pm 20\%$. Therefore little weight should be put on any particular estimate.

The estimates of the effects of environmental conditions on kiwi call counts provided the opportunity to evaluate the significance of these factors. This analysis proves the value of recording ground moisture, wind and rain which appear to make a difference to kiwi call counts. If practicable, efforts could be made to carry out counts when these factors are at a consistent level, preferably when they enhance rather than reduce call counts. Whenever possible, variability in environmental factors should be minimised. Where there is variability, the factors need to be recorded, and taken into account in the analysis. It would be desirable to put particular emphasis on ground moisture, wind and rain as factors that are now established as significant.

The accumulation and analysis of further data over time and for more stations will provide the potential to gain more certainty about call trends, the impact of covariates, and the impact of different management regimes.

5. Conclusions and recommendations

This analysis proves the value of a kiwi call method for monitoring North Island brown kiwi; the method has potential for discriminating between effects of different levels of management.

We recommend the continuation of kiwi listening at these and other sites in Northland as a means of detecting medium and long-term changes in kiwi numbers. With an increase in the number of management initiatives for kiwi in Northland (including many private ventures), it will be most cost-effective to establish listening stations in representative parts of each management area. Related research currently underway on the seasonal ratios between call counts and birds present (E. Craig and J. McLennan, personal communication) will enable managers to determine more accurately from call-count data the numbers of birds present at a given site.

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Appendix. Station ranking data and estimated annual percentage rate of change in rate of kiwi call counts for the 23 kiwi listening stations

Station No.	Locality	Observers	Predator control rating	Advocacy rating	Estimated annual % change
Northern					
1	Diggers Valley	R. Renwick	2	3	9.1
2	Takahue	F. Schou	1	3	16.3
5	Kaiaka	T. Higginson	2	3	14.6
7	Puketi Forest	S. McManus	1	1	5.2
8	Puketi Scenic Reserve	I. Wilson	1	2	−1.9
Eastern					
10	Marsden Cross	L .Charman	1	3	−0.8
11	Puketotara	H. MacMillan	1	3	−5.4
12	Rangitane	A. Walker, K. Walshe	0	1	−2.3
13	Waitangi No. 12	D. Harrison	0	0	−2.2
14	Mt Bledisloe	L. Honnor, R. Brown	0	1	−26.6
15	Tikitikioure	M. McGlynn, J. Maxwell	0	1	−17.2
Western					
16	Katui	T. Herbert	0	1	−17.7
17	Trounson	M. Leach	3	3	2.6
18	Waipoua/Cathedral	R. Cowan, A. Kereopa	1	2	0.1
19	Waipoua Lookout	T. Herbert	1	1	−10.6
20	Paerata	G. Coulston	0	0	−13.2
Southern					
21	Glenbervie 7A	G. Grant	0	1	−14.8
22	Glenbervie	P. Miller	0	1	13.7
23	Marlow	R. Pierce	2	2	4.0
24	Purua	P. Anderson	1	3	1.5
25	Rarewarewa	A. Booth, H. Robertson	2	3	−2.3
26	Mimiwhangata	G. Wake	1	1	−5.0
27	Sandy Bay	N. Pulman	1	1	9.3

Note: An additional 10 stations (i.e. stations 3,4, 6, 9 and 28–33) were not used in the analysis relating rate of call count change to level of management because of incomplete data or fewer years of study.

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