Could changes in rook population characteristics cause collapse of rookeries?

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Summary

Project and Client

- Horizons Regional Council is optimising its control strategy for invasive rooks (*Corvus frugilegus*) and in 2012 sought advice from Landcare Research (Envirolink project 1086-HZLC86) on the likely impacts on rook populations of baiting nests with the toxin DRC-1339. This control method primarily targets females and juveniles at the nest.

Objectives

The project has two parts, which will help to improve the efficiency and effectiveness of rook control in New Zealand:

- Modelling how changes in sex ratio (shortage of females) and average age (shortage of young birds) could lead to collapse of rook populations
- Identifying control targets, i.e. the intensity and duration of nest baiting required to achieve rookery collapse due to changes in age and sex ratio

Methods

- A population model was created and used to predict the trajectory of rook populations under various control scenarios. Mortality of rooks due to nest baiting was set to vary between males and females, and between juveniles, yearlings and adults. Model parameters were set using published and unpublished information, including discussions with rook control practitioners from Horizons and neighbouring regions. We modelled kill rates ranging from 60 to 90% for juveniles and adult females, and 0 to 30% for male rooks. The model assumed no immigration of rooks from surrounding regions. The model produced annual estimates of male and female rook numbers in Horizons Region under various control scenarios. It also estimated the probability of extinction, and the number of years to achieve this.

Results

- Without rook control, the model predicted rapid population growth.
- Using any of the kill rates that we judged a priori as plausible, the model predicted a 100% probability of effective extinction (i.e. all females removed) of the rook population in Horizons Region.
- Depending on the modelled kill rates, estimated time to effective extinction ranged from 7 ± 1 to 19 ± 3 years.
- Without any further control, total extinction (i.e. death of all remaining males) would be expected to occur ≤ 25 years after all females are removed.
- To achieve effective extinction of rooks within 50 years, at least 80% of active nests must be targeted, and at least 50% of juveniles and adult females at those nests must be

killed each year. However, higher kill rates will lead to much faster eradication, saving considerable time and money.

Conclusions

- Current nest baiting practices should achieve effective extinction of rooks in Horizons Region within approximately 7–19 years.
- Immigration of rooks from neighbouring regions would delay or prevent their eradication from Horizons Region.
- Any active nests that repeatedly escape treatment could delay or prevent eradication.

Recommendations

- Current nest baiting practices should continue in Horizons Region until no active nests can be found.
- Every effort should be made to maximise:

    1. Kill rate of juveniles and adult females, and

    2. Detection and treatment of active nests.

- Information about rates of immigration from surrounding regions should be obtained and incorporated into the model to evaluate the impact of immigration on probability and time to extinction of rooks in the Horizons Region.
- Surviving males should be targeted by alternative removal methods such as ground baiting and shooting because they will present an ongoing risk to Horizons Region and its neighbours through potential breeding with immigrant females.

1 Introduction

Rooks (*Corvus frugilegus*) are considered pests in New Zealand due to their impacts on crops and pastures (NPCA 2006; Cowan et al. 2010). Horizons Regional Council is optimising its control strategy for invasive rooks and in 2012 sought advice from Landcare Research (Envirolink project 1086-HZLC86) on the likely impacts on rook populations of baiting nests with the toxin DRC-1339. This control method primarily targets females and juveniles at the nest.

2 Background

Nest baiting with DRC-1339 primarily targets females and juveniles at the nest, so survivors are predominantly adult males (NPCA 2006). This is hypothesised to create a shortage of females and young birds of breeding age, and could therefore cause rook populations to collapse. Such collapses have been noted by field staff (e.g. Martyn & Dodd 2011).

Thus, it may be possible to extirpate rook populations without having to target every individual bird. Such an approach could greatly improve the effectiveness and efficiency of rook control. This aligns with the rook strategy in Horizons regional pest management plan, which aims to eradicate rooks from the region.

This work builds on a previous Envirolink project ‘Future options for the management of rooks (*Corvus frugilegus*)’ (Cowan et al. 2010). The advice has the potential to progress rook management from ongoing control (requiring indefinite commitment of resources) to eradication (offering freedom from the impacts of rooks, and the cost of their control).

3 Objectives

The project has two parts, which will help to improve the efficiency and effectiveness of rook control in New Zealand:

- Modelling how changes in sex ratio (shortage of females) and age structure (shortage of young birds) could lead to collapse of rook populations
- Identifying control targets, i.e. the intensity and duration of nest baiting required to achieve rookery collapse due to changes in age and sex ratio

4 Methods

4.1 Description of population model

We created and used a population model to predict the trajectory of the rook population in Horizons Region under varying scenarios of lethal control. The model describes annual changes in the numbers of male and female rooks in three age classes: juveniles aged 0–1 years (‘0’); yearlings aged 1–2 years (‘1’); and adult birds ≥ 2 years old (‘2+’) (Figure 1). The model can simulate different levels of lethal control for each sex and age class.

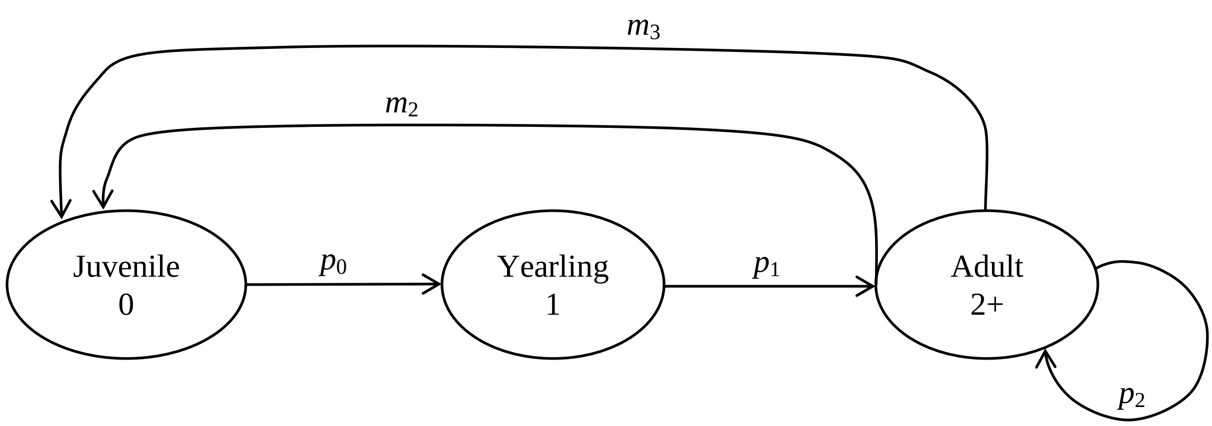

Figure 1 Schematic representation of the rook population model with three age classes. Each year a proportion of birds (*p*) survive. The number of chicks hatched (*m*) varies between 2-year-old females (m_2) and older females (m_3).

The population was modelled using annual time steps with numbers estimated after the annual pulse of breeding (‘post-breeding census’). The number of chicks hatching each year (the number appearing in the 0 age-class) was the product of the number of adult females in the previous year, their annual survival and their productivity. Based on an average fledging rate of 1.5 young per breeding female (NPCA 2006) and an average survival from hatching to fledging of 0.6 (Coleman 1972; Røskaft et al. 1983) the average productivity was assumed to be 2.5 chicks hatched per breeding female per year. Females first breed at 2 years of age but their productivity is generally lower, hatching one-third fewer chicks on average than birds that are over 2 years old (Røskaft et al. 1983). Assuming first-time breeders make up one-fifth of the breeding population this corresponds to age-specific productivities of 1 chick hatched per 2-year old female and 3 chicks hatched per experienced female. The sex ratio at hatching was assumed to be even. The number of birds surviving the year and moving into the next age class (0 to 1, 1 to 2+) or surviving the year (2+) was a product of their maximum annual survival rate tempered by a density-dependence factor, which meant that annual survival decreased the nearer the population was to its carrying capacity, i.e. the maximum number of birds the habitat could support. This density-dependence effect was more marked on the juvenile birds, reflecting their enhanced susceptibility to mortality from summer food shortages (Patterson et al. 1988). Control of rooks using toxic gel baits at nest sites was assumed to occur after annual mortality and recruitment and the proportional kill varied with age and sex because breeding males are more likely to be away from the nest given their greater role in feeding the nestlings (NPCA 2006). Also, non-breeding, 1-year-old birds are unlikely to spend much time at nest sites, and are therefore less likely to be exposed to the poison (Patterson & Grace 1984; NPCA 2006). Annual changes in rook numbers can be summarised by a system of discreet-time equations. For example, the number of 1-year-old females ($N_{f,1,t}$) in year t is the number of juvenile females ($N_{f,0,t-1}$) in the previous year ($t-1$) that survived the year and recent control:

$$N_{f,1,t} = N_{f,1,t-1} * p_0 * \exp(-d_j * N_{t-1}) * (1-q_{f,1})$$

where N_{t-1} is the total population of rooks (summed over all age and sex classes) and the other parameters and their values are as described above and in Table 1. These parameters were estimated using various published and unpublished sources (Horizons Regional Council 2003, 2004; NPCA 2006; Porter et al. 2008; Cowan et al. 2010).

Table 1 Default parameters for the rook population model. The effects of rook control can be simulated by varying the proportional kill for each sex and age category

Parameter description	Symbol	Value	Unit
Sex ratio (proportion of birds female) at hatching	x	0.5	-
Maximum survival from 0 (hatching) to 1 year old	p_0	0.5	yr^{-1}
Maximum survival from 1 to 2 years old	p_1	0.95	yr^{-1}
Maximum survival of >2 year olds	p_2	0.95	yr^{-1}
Chicks hatched per 2-year-old female	m_2	1	yr^{-1}
Chicks hatched per >2-year-old female	m_3	3	yr^{-1}
Strength of density-dependence on 0 to 1-year-old (juvenile) mortality	d_J	0.12	-
Strength of density-dependence on >1-year-old (adult) mortality	d_A	0.02	-
Proportional kill from toxin on females 0 year old	$q_{f,0}$	0.6–0.9	yYr^{-1}
Proportional kill from toxin on females 1 year old (yearlings)	$q_{f,1}$	0	yr^{-1}
Proportional kill from toxin on females 2+ years old	$q_{f,2}$	0.6–0.9	yr^{-1}
Proportional kill from toxin on males 0 year old	$q_{m,0}$	0.6–0.9	yr^{-1}
Proportional kill from toxin on males 1 year old (yearlings)	$q_{m,1}$	0	yr^{-1}
Proportional kill from toxin on males 2+ years old	$q_{m,2}$	0–0.3	yr^{-1}
Proportion of active nests controlled	z	0.8–0.9	-

Both demographic and environmental stochasticity were included in the model. Demographic stochasticity is random or chance variation in individual survival or reproduction, and was modelled by drawing the number of birds surviving or reproducing from a binomial distribution. Environmental stochasticity is temporal variation in survival rates due to changing environments, for example lower survival rates in years of drought. We assumed environmental stochasticity had the same effect on each age class, and modelled this by drawing annual survival rates from a multivariate normal distribution with a specified covariance matrix.

4.2 Estimating kill rates

Based on published and unpublished information, as well as conversations with rook control practitioners, we estimated the range of kill rates that we considered to be realistic for juveniles, adult males and adult females. Because adult female rooks sit on the nest during the breeding period (Patterson & Grace 1984), they and their unfledged young are highly likely to be killed by nest baiting. Estimated kill rates for rooks present at the nest (predominantly juveniles and adult females) are usually over 90%, but can be as low as 70% in some years (e.g. due to unfavourable weather during aerial nest-baiting operations). We therefore modelled kill rates for juvenile and adult female rooks ranging from 60 to 90%.

Adult male rooks spend much of their time away from the nest, and are therefore less likely to be killed by nest baiting (Purchas 1979; NPCA 2006). However, males do visit the nest to feed their mate, and are therefore likely to be at some risk of ingesting the toxin. Of approximately 100 dead rooks recently recovered after a nest-baiting operation, around 10% were male (E. Dodd, Horizons Regional Council, pers. comm. 2012). We considered that this may be a minimal estimate of male mortality since death occurs some hours after poisoning (Nelson 1994), and some males would probably die away from the rookery where they may not be found. Thus, for adult male rooks we modelled kill rates ranging from 0 to 30%. Yearlings were assumed not to be killed by nest baiting (NPCA 2006).

Although all known rookeries in the region are targeted by aerial baiting (Horizons Regional Council 2006a,b), additional active nests are occasionally discovered, suggesting that <100% of active nests are baited in any given year (E. Dodd, pers. comm. 2012; A. Beer, Hawke's Bay Regional Council, pers. comm. 2012). To account for imperfect detection of active nests, we ran the model initially with 90% of active nests being targeted each year. This was varied in the process of identifying control targets (see Section 4.4).

4.3 Estimating time to extinction

We ran the model with the range of estimated kill rates described above to produce best-case and worst-case scenarios for the outcomes of rook control. In each case we ran the model for 50 years. The model was run 100 times for each scenario, and the average time to extinction (± standard deviation) was calculated from the 100 resulting estimates.

In population viability analysis, it is common practice to define extinction as the absence of at least one sex (Miller & Lacy 2005). We therefore defined the rook population to be 'effectively extinct' when all females had been removed. However, males could potentially live for many years after the last female is removed. Thus, we also estimated the time to 'total extinction', which we define as the absence of rooks of either sex from the region. Once all females were removed there would be no active nests. We therefore assumed that nest baiting would cease at this point and remaining males would die of natural causes. Based on a maximum recorded age for a rook of 23 years (Euring 2012), we estimated that the last male would die in ≤ 25 years after removal of all females.

For comparative purposes, we also ran the model with kill rates of zero for all sex and age classes. This simulated a scenario in which no further rook control was undertaken in the region.

4.4 Identifying control targets

To estimate the minimum level of rook control that would lead to extinction, we ran the model with incremental reductions in (1) kill rate of juveniles and adult females, and (2) percentage of active nests targeted. First we set the kill rate of adult males at zero, then reduced the kill rate of juveniles and adult females by increments of 10%. Next we set the kill rate of juveniles and adult females to 60% (leaving that of males at 0%) and reduced the proportion of active nests treated by increments of 10%. For both kill rate and proportion of nests treated, we continued to make incremental reductions until the model no longer predicted a 100% probability of extinction within 50 years.

5 Results

5.1 Estimating time to extinction

Without rook control, the model predicted a 0% probability of extinction. Instead there was rapid population growth (Figure 2), consistent with the model predictions reported by Cowan et al. (2010). However, using any of the kill rates that we judged a priori as plausible (Table 1), the model predicted a 100% probability of effective extinction (i.e. all females removed) of the rook population in Horizons Region.

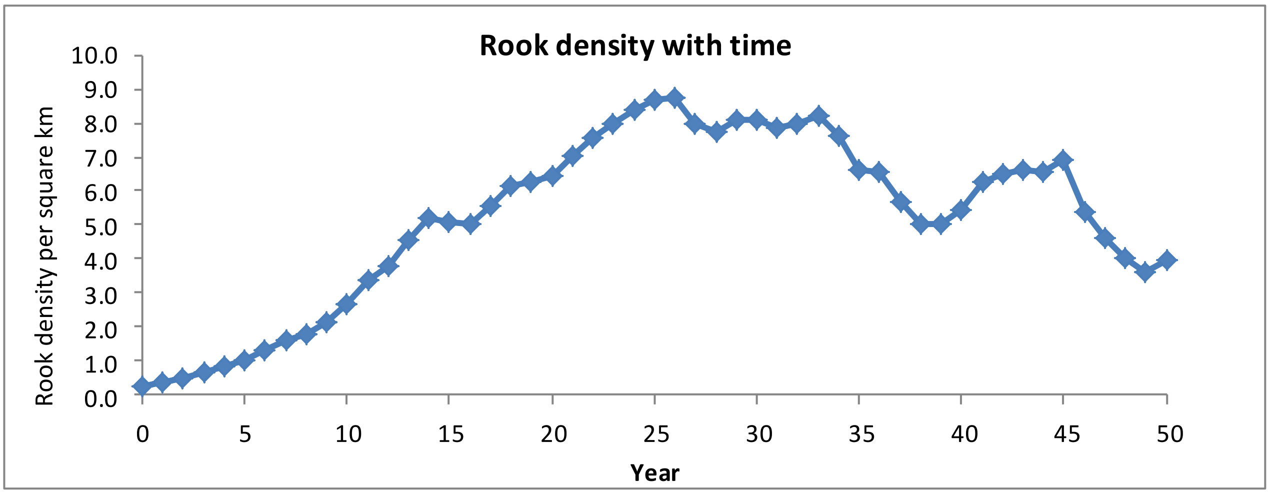

Figure 2 Predicted trajectory of the rook population in Horizons Region with no control.

In the best-case scenario (90% kill rate for juveniles and adult females; 30% for adult males) the model predicted effective extinction after 7 ±1 years, which would lead to total extinction in ≤ 32 years. Reducing the kill rate of adult males from 30% to 0% (while maintaining that of juveniles and adult females at 90%) had no effect on the model predictions; effective extinction was still predicted after 7 ± 1 years. Conversely, when the kill rate of juveniles and adult females was reduced from 90% to 60% (while maintaining that of males at 30%), the model predicted a much longer time to effective extinction of 19 ±3 years, in which case total extinction would occur in ≤ 45 years. Once again, this prediction was unchanged by varying the kill rate of adult males between 0% and 30%.

5.2 Identifying control targets

Predicted probability of extinction within 50 years fell below 100% when the kill rate of juveniles and adult females was reduced below 50%, or when kill rate was 60% and the proportion of active nests targeted each year was reduced below 80%. Below these thresholds, probability of effective extinction declined rapidly to zero (Figure 3).

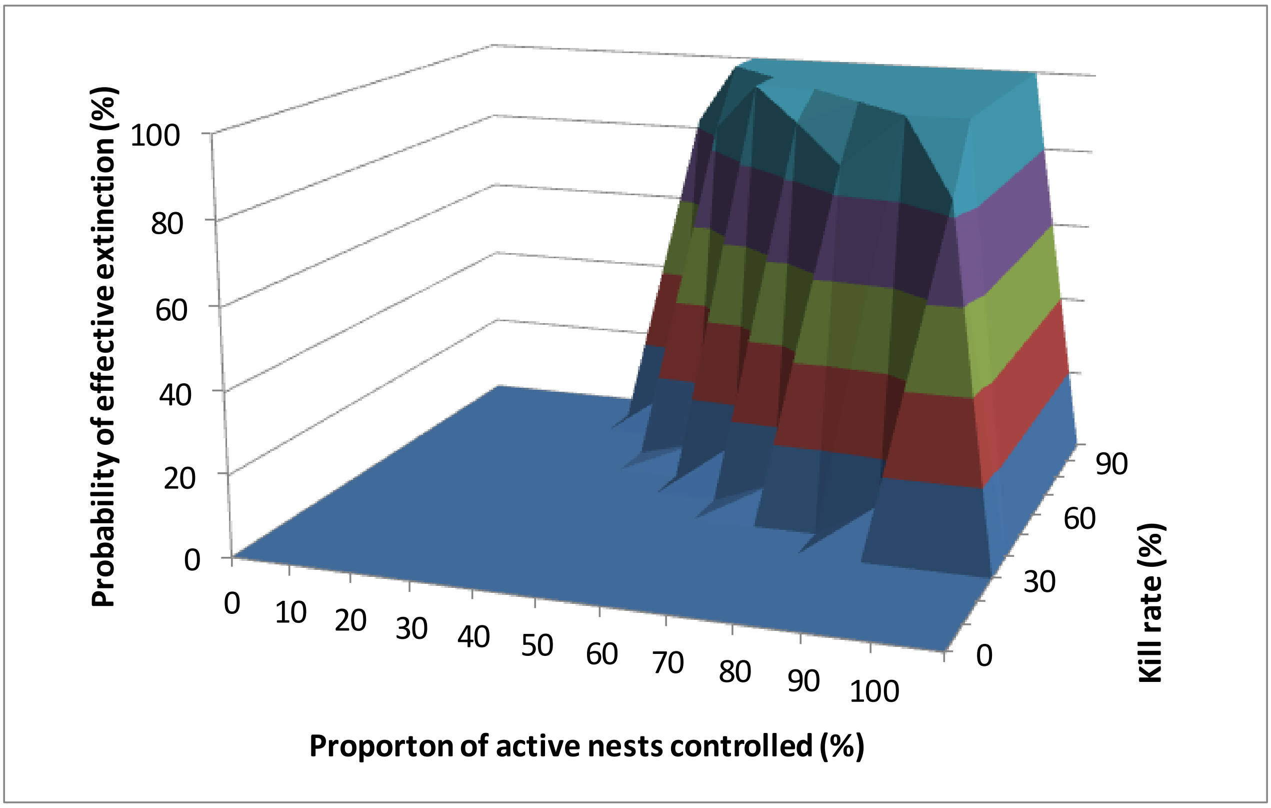

Figure 3 Relationship between kill rate of rooks, proportion of active nests controlled each year and probability of effective extinction in Horizons Region within 50 years.

6 Conclusions

Our model predicts that the current nest-baiting practices being applied in Horizons Region should achieve regional eradication of rooks. Depending on the kill rates of juveniles and adult females, effective extinction (absence of females) should occur within approximately 7–19 years, with total extinction following after another 25 years or less. Numbers of active nests in Horizons Region have declined rapidly in recent years (Martyn & Dodd 2011), while large numbers of inactive nests suggest that males already outnumber females in the population (E. Dodd, pers. comm. 2012). These data are consistent with the predictions of the model. The model was not sensitive to changes in the kill rate of adult males, suggesting that targeting these birds may be relatively unimportant to the outcome of control. However, the model predictions have two important caveats:

1. The model assumed no immigration of rooks into the region. If immigration does occur, this could delay or prevent eradication. Immigrating female rooks would be of particular concern.

2. Although the model accounts for imperfect detection of active nests, it assumes that the same nests do not go undetected for many years. If some active nests repeatedly escape treatment, rook populations could persist much longer than predicted by the model, and perhaps indefinitely.

Because our model considered only nest baiting, all rook control was assumed to cease after the last females had been removed (since there would no longer be any active nests to bait). This would potentially allow some males to survive for many years before eventually dying of natural causes. Removal of surviving adult males may be advisable as a precautionary measure. This might be achieved by ground baiting, with small numbers of remaining males possibly being shot at long range with a suppressed rifle. As long as males persist in the region there is a risk that immigrant females from neighbouring regions will breed with the remaining males. In the absence of females it is also possible that the surviving male rooks would disperse in search of mates, potentially contributing to rook populations in neighbouring regions.

7 Recommendations

We recommend:

- Current nest baiting practices continue in Horizons Region until no active nests can be found.
- Every effort should be made to maximise:

    1. Kill rate of juveniles and adult females, and

    2. Detection and treatment of active nests.

This should ensure rapid removal of all female rooks, leading to financial savings as no further nest baiting will then be required.

- Information about rates of immigration from surrounding regions is obtained and incorporated into the model to evaluate the impact of immigration on probability and time to extinction of rooks in the Horizons Region.
- Surviving males be targeted by alternative removal methods such as ground baiting and shooting because they will present an ongoing risk to Horizons Region and its neighbours through potential breeding with immigrant females.

8 Acknowledgements

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9 References

Coleman JD 1972. The breeding biology of the rook *Corvus frugilegus* L in Canterbury, New Zealand. Notornis 19: 118−139.

Cowan P, Booth L, Duckworth J, Glen A 2010. Future options for the management of rooks (*Corvus frugilegus*). Envirolink Project HZLC75. Landcare Research.Contract Report LC1011/052 for Horizons Regional Council.

Euring 2012. European longevity records. http://www.euring.org/data_and_codes/longevity-voous.htm (accessed 23 May 2012).

Horizons Regional Council 2003. Post Operative Report: Rook Operations 2002–03. Palmerston North, Horizons Regional Council.

Horizons Regional Council 2004. Post Operational Report: Rook Control (2003–04). Palmerston North, Horizons Regional Council.

Horizons Regional Council 2006a. Regional Animal Pest Management Strategy (RAPMS) Operational Plan 2006−07. Palmerston North, Horizons Regional Council.

Horizons Regional Council 2006b. Regional Animal Pest Management Strategy (RAPMS) Operational Report 2005–06. Palmerston North, Horizons Regional Council.

Martyn B, Dodd E 2011. Regional Pest Animal Management Strategy (RPAMS) Monitoring Report 2010–11. Palmerston North, Horizons Regional Council.

Miller PS, Lacy RC 2005. VORTEX: A Stochastic Simulation of the Extinction Process. Version 9.50 User’s Manual. Apple Valley, MN, Conservation Breeding Specialist Group (SSC/IUCN).

Nelson PC 1994. Bird control in New Zealand using alpha-chloralose and DRC1339. In: Halverson WS, Crabb AC eds Proceedings of the 16th Vertebrate Pest Conference. Davis, University of California. Pp. 361−364.

NPCA 2006. Pest Rooks: Monitoring and Control. Wellington, National Possum Control Agencies.

Patterson IJ, Grace ES 1984. Recruitment of young rooks, *Corvus frugilegus*, into breeding populations. Journal of Animal Ecology 53: 559−572.

Patterson IJ, Dunnet GM, Goodbody SR 1988. Body weight and juvenile mortality in rooks *Corvus frugilegus*. Journal of Animal Ecology 57: 1041−1052.

Porter RER, Clapperton BK, Coleman JD 2008. Distribution, abundance and control of the rook (*Corvus frugilegus* L.) in Hawke's Bay, New Zealand, 1969–2006. Journal of the Royal Society of New Zealand 38: 25−36.

Purchas TPG 1979. Breeding biology of rooks (*Corvus frugilegus* L.) in Hawke's Bay, New Zealand. New Zealand Journal of Zoology 6: 321−327.

Røskaft E, Espmark Y, Järvi T 1983. Reproductive effort and breeding success in relation to age by the rook *Corvus frugilegus*. Ornis Scandinavica: 169−174.