SHORT COMMUNICATION

Increased predation on pukeko eggs after the application of rabbit control measures

John Haselmayer[1] and Ian G. Jamieson*
Department of Zoology, University of Otago, PO Box 56, Dunedin, New Zealand
[1]Present address: Department of Biology, McMaster University, Hamilton, Ontario, L8S 4K1, Canada
(E-mail: haselmjw@mcmaster.ca)
* Corresponding author (E-mail: ian.jamieson@stonebow.otago.ac.nz)

Abstract: We have been studying the social behaviour and ecology of pukeko (*Porphyrio porphyrio*) for over five years at a study site in the lower Taieri River, Otago New Zealand. After an application of rabbit poison in 1995 and the illegal release of rabbit haemorrhagic disease (RHD) in 1997, there was strong anecdotal evidence that rabbit (*Oryctolagus cuniculus*) abundance on and around our study site had been substantially reduced. In a retrospective analysis, we compared predation rates on the nests of pukeko over a four-year period (1991-1994) before the application of these measures and one year after the release of RHD (1998). Significantly more nests were predated in 1998 than in previous years. While we recognise a number of possible explanations for this result, we suggest that one of the most plausible reasons for the increase in predation rates is a shift in diet by the rabbit specialist predator, the Australasian harrier (*Circus approximans).*

Keywords: Australasian harrier; nest predation; New Zealand; prey-switching; rabbit control; RHD.

Introduction

Rabbit haemorrhagic disease (RHD) was illegally introduced into Central Otago in the spring of 1997 as a means of controlling rabbit (*Oryctolagus cuniculus* L.) abundance. Its short-term effects on rabbit populations were highly variable, with kills ranging from over 95% to almost nil (Parkes *et al*., 1999). Little is known of the long-term effects of RHD on rabbit populations or the indirect effects of declines in rabbit abundance on other species in the community.

One of the concerns regarding the introduction of RHD to New Zealand is the possibility that rabbit-specialist predators [e.g. ferrets (*Mustela furo* L.), cats (*Felis catus* L.), stoats (*Mustela erminea* L.), and Australasian harriers (*Circus approximans* Peale)] will shift their diet to native prey in the absence of rabbits (Norbury *et al*., 1998; Norbury, 1999). A few studies from New Zealand and overseas have shown an increase in native prey in the diets of predators after experimentally induced declines in rabbit abundance [reviewed by Norbury (1999)]. In New Zealand, these studies have focussed on semi-arid tussock grassland of Central Otago, an area that supports very high rabbit populations and several vulnerable native bird species. The purpose of this paper is to report on an increase in predation on pukeko (*Porphyrio porphyrio* L.) eggs after an RHD outbreak in an area outside of Central Otago.

Methods

We collected the data incidentally to a study of the breeding behaviour of pukeko (or purple swamphen) (Jamieson *et al*, 1994; Jamieson, 1997; Haselmayer, 2000). The pukeko is a large gallinule, which builds a large, shallow cup nest woven from grasses and reeds. The nest is typically placed in the centre of a clump of reeds or in raupo (*Typha spp.*) over shallow water or within about one meter of the water's edge. Both sexes incubate the eggs, which hatch asynchronously after 23-27 days. The precocial chicks are capable of leaving the nest within hours of hatching, but often remain in the nest for two or three days (Craig and Jamieson, 1990).

The study was carried out over five breeding seasons (September–January), i.e. 1991-1994 inclusive

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and 1998. Our main study site was the Otokia Wildlife Reserve, an 11.2 ha area of reclaimed wetland and semi-flooded pasture, and adjacent paddocks and swampy areas 30 km south of Dunedin. We found nests by observing pukeko from hides located on an adjacent hillside and from vehicles on elevated roadways and flood banks, then searching areas where we observed nesting behaviour. We subsequently checked all nests every 1-2 days throughout the incubation and hatching periods. We scored each nest as belonging to one of three categories. A nest from which all the eggs disappeared or were destroyed was scored as "predated" if the previous nest check had confirmed the birds' continued attendance at the nest (by either the presence of a newly laid egg or by the eggs' being warm). If the previous nest check failed to confirm the birds' continued attendance at the nest (cold eggs, and no new eggs), it was scored as "deserted." If at least one egg from a nest hatched successfully, the nest was scored as "hatched." For all predation events in 1998, we made descriptive notes of the sign left by the predator, but made no concerted efforts (e.g. video) to identify the nest predators.

We compared predation rates in 1998 (post-RHD) with previous years. Our behavioural studies concentrated on finding nests early in the egg-laying period. We did come across a few nests that were in the later stages of the incubation period and the inclusion of these could have affected the probability of observing a predation event. Because our sample sizes were relatively large, we therefore included in our analysis only those nests that were found during the egg-laying period. In addition, because we manipulated nests in 1998 by adding eggs to some nests during the laying period, we report results that both include and exclude manipulated nests.

The National Institute of Water and Atmospheric Research (NIWA) supplied rainfall data for the area (as referred to in the Discussion).

Results

Over the five field seasons, we found a total of 112 nests during the laying period of which 50 hatched, 28 were predated, and 17 were deserted. The mean number of territories per year in the study area (mean ± SE) was 16.8 ± 2.3. In any one year, a single territory generated from one to ten nests (1.8 ± 0.3) as a result of renesting after predation or desertion. Due to searching a larger

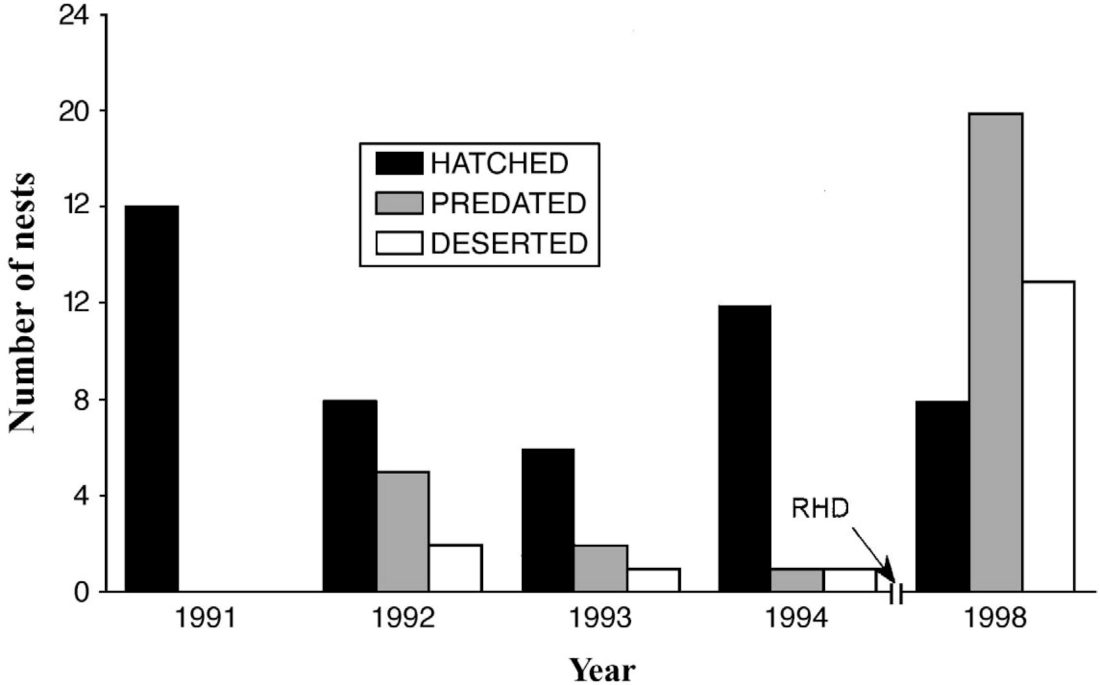

Figure 1. Absolute numbers of hatched, predated and deserted nests by year. None of the nests we observed in 1991 were predated or deserted, so absence of columns does not indicate a lack of data. RHD = rabbit haemorrhagic disease.

area, we found more territories with active nests in 1998 (24 compared with 16, 12, 16, and 16 for 1991-1994 respectively), and thus more nests during the egg-laying period (45 in 1998 compared with 16, 18, 16, and 17 in 1991-1994, respectively). The distribution of hatched, predated, and deserted nests over the five years is given in Fig. 1.

To compare predation rates between 1998 and previous years, we pooled the data from the three years 1992-1994 to generate expected values in a contingency analysis. The pooling of these data is justified by the lack of significant heterogeneity in the predation rates from the three years (G_H =3.27, d.f.=2, P>0.10). However, we excluded the 1991 data from the analysis because a G-test did show evidence of heterogeneity among the predation rates from all four years 1991-1994 (G_H=8.68, d.f.=3, P<0.05). Because 1991 is the year that is most dissimilar to 1998 in terms of nest predation (none of our observed nests were predated or deserted in that year), its exclusion will, if anything, underestimate the implied predation response. Predation rates in 1998 were significantly greater than in previous years (manipulated nests included: χ^2 =19.12, d.f.=1, P<0.001; manipulated nests excluded: χ^2=28.95, d.f.=1, P<0.001) (Fig. 1).

To compare desertion rates between 1998 and previous years, we pooled the data from all four years 1991-1994 because a G-test showed no evidence of heterogeneity among them (G_H=3.23, d.f.=3, P>0.10). Desertion rates in 1998 were much higher than in previous years (manipulated nests included: χ^2=35.96, d.f.=1, P<0.001; manipulated nests excluded: χ^2=9.04, d.f.=1, P<0.005) (Fig. 1).

Of three predation events observed in 1998, all involved Australasian harriers. At all three predated nests, many shell fragments and a few half-eaten eggs were found. Fourteen of the 20 nest predations in 1998 involved similar sign. The remaining six left very clean sign, the eggs having simply disappeared. Data on predation sign were not collected in 1991-1994, although harriers were observed eating pukeko eggs on two occasions.

Discussion

Efforts at rabbit control in New Zealand and the attendant studies of the ecological effects of such control have naturally focused on areas of high rabbit abundance, such as the semi-arid high country of Central Otago (Pierce, 1987; Norbury and McGlinchy, 1996; Norbury and Heyward, 1997). Unfortunately, this means that rabbit count data are lacking for areas of lower rabbit abundance, such as our study site in the lower Taieri River flood plain. Without these data, we cannot establish a numerical correlation between rabbit numbers and predation rates on pukeko nests. However, we know that RHD was released in our study area in the summer of 1997, shortly after its release in Central Otago, and that rabbit poison was applied to our study area in 1995. An adjacent landowner informed us that, before 1995, rabbits were common on his land, that their abundance decreased after the 1995 poisoning, and that he has not seen a single rabbit in the area since the release of RHD in the summer of 1997. Though not quantitative, this anecdotal evidence suggests that, between 1994 and 1998, there was a significant decrease in the rabbit population on our study site.

Our data provide evidence of an increase in predation and desertion rates of pukeko nests between 1994 and 1998. There is anecdotal evidence of a dramatic decrease in rabbit numbers during this time. We directly observed three Australasian harriers predating nests during the 1998 field season and much of the sign at other nests suggested harrier predation. There are several explanations that could account for these results.

It is possible that predators from nearby areas of previously high rabbit abundance (e.g. Central Otago) may have dispersed into our study site when rabbit populations there declined during the 1997 RHD epidemic. However, most dispersing predators presumably would not have remained in our study area given the lack of rabbits and the relatively small population of pukeko and their eggs as alternative prey. Furthermore, we did not notice any obvious increase in harrier numbers between 1994 and 1998.

The observed decline in rabbit populations may have been simply coincidental and there are several alternative explanations that could account for the observed increase in predation rates in 1998. First, it is possible that our activities at the nests in 1998 caused greater disturbance than in previous years and that predators took advantage of the window during which the adults were away from the nest. Certainly, the fact that we also see a significant increase in desertion rates in 1998 suggests that this could have been the case. However, we made similar numbers of visits in all years, and although our visits were longer (and therefore disturbance higher) at nests to which eggs were added in 1998, we still see higher predation and desertion rates in 1998 when these nests are removed from the analysis. Furthermore, after each nest visit, we watched the nest area from a safe distance for 15 min to ensure that no harriers approached the nest during this time. We doubt that our activities at nests contributed to the increased predation rates.

Second, more of the 1998 nests could have been in marginal habitats where they might be more susceptible to predation. Indeed, we found more territories in 1998 largely because we expanded our study site into surrounding paddocks where the nests are less concealed than on the main site. However, it was not the case that a disproportionate number of the predated nests were on marginal territories. Six out of 16 (37.5%) nests from 7 marginal territories hatched successfully in 1998, compared to 8 out of 29 (27.6%) nests on 17 non-marginal territories. If anything, the inclusion of marginal territories in 1998 reduced our estimate of predation rates.

Third, the three months leading up to the 1998 breeding season were exceptionally dry in the area of our study site. Only 61.4 mm of precipitation fell between June and August, 1998 compared with a mean (SE) of 143.6 ± 28.8 for the same months in 1991 – 1994. Thus, large areas of our study site, which would normally have been under at least a few centimetres of water, were completely dry. This would allow greater access to nests for terrestrial predators, particularly mustelids (Craig, 1980). However, only 6 of the 20 predation events in 1998 showed the "clean" sign typical of mustelid predation (Moors, 1983). The other 14 showed "messy" sign similar to the three harrier predations that we observed directly but that could also be attributed to ship rats (*Rattus rattus* L.) (Brown *et al.*, 1998). It should be noted here that Brown *et al.* (1998) question the utility of sign for identifying nest predators, at least for passerines. Nevertheless, we suspect that harriers were the main predators at our nests both because of sign and because we frequently saw harriers hunting directly over the study site. However, in the absence of conclusive data on the identity of the predators, we cannot be certain of the influence water levels have on predation rates for pukeko nests.

We propose that the increase in predation rates in 1998 may have resulted from the decline in rabbit populations following the 1995 poisoning and the 1997 RHD epidemic; i.e. rabbit specialist predators in the area responded to a decrease in rabbit abundance by exploiting less preferred prey, including pukeko eggs. This response has been documented for harriers (Pierce 1987; Pierce and Maloney, 1989), ferrets and cats (Pierce, 1987; Norbury *et al.*, 1998) in New Zealand as well as for foxes and stoats in England (Sumption and Flowerdew, 1985). Although the evidence supporting the link between RHD, rabbits, harriers, and pukeko nests is circumstantial, it is a hypothesis worthy of further investigation.

Because this was not a planned experiment designed to investigate predation, we are unable to make a conclusive statement about the cause of the increase in predation in 1998. The two most plausible explanations are the lack of precipitation in 1998 and the decline in rabbit numbers between 1994 and 1998. We feel that even the possibility that RHD could cause such a dramatic increase in predation at the nests of a native bird species should be of concern to managers and conservationists. More extensive studies are needed to adequately document and quantify this effect and we hope that this note will spur further investigations into the broader ecological implications, both positive and negative, of RHD in New Zealand.

Acknowledgements

We thank all the field assistants who helped locate pukeko nests over the years, particularly Heather Shaw for her work in 1998. James Adam, Otago Fish and Game, and the Department of Conservation allowed access to the study site and surrounding land. Kevin McGill of NIWA kindly supplied the rainfall data. Grant Norbury, Tim Demons, Jim Quinn, and two anonymous reviewers provided helpful comments on the manuscript. JH was funded by a Natural Sciences and Engineering Research Council (NSERC) of Canada postgraduate scholarship and received travel assistance through a NSERC grant to Dr. James Quinn. Our pukeko research is funded by the University of Otago.

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