

FORUM ARTICLE

Which factors limited stitchbird population growth on Mokoia Island?

Matthew Low

Department of Ecology, Swedish University of Agricultural Sciences, Box 7044, 75007, Uppsala, Sweden.
(Email: matt.low@ekol.slu.se)

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Abstract: Reintroduction programmes need to be monitored as a way of gauging potential causes of their success or failure. This, in turn, can be used to improve the likelihood of future translocation success. Since the 1990s, stitchbird (or hihi: *Notiomystis cincta*) translocations have been intensively monitored, with comparisons between two of these projects (Tiritiri Matangi Island – a successful introduction, and Mokoia Island – an unsuccessful introduction) often compared and contrasted as a means of identifying factors important in translocation success for this species. A consistently low adult survival rate on Mokoia Island in conjunction with a study showing a high prevalence of aspergillosis (a fungal disease of the respiratory tract caused by *Aspergillus fumigatus*) in adult stitchbirds led to this disease being commonly discussed as a major factor responsible for the difference in translocation outcomes. However, *A. fumigatus* infection rates have never been compared between the two stitchbird populations; thus, population differences in adult survival may have resulted from other factors. One possibility is that survival differences between populations were influenced by differing predation pressures from morepork (or ruru: *Ninox novaeseelandiae*). Evidence of stitchbird predation by moreporks and the fact that morepork density on Mokoia Island was markedly higher than on Tiritiri Matangi Island provides some support for this hypothesis. It is important that all plausible hypotheses for differences in survival be considered so that we can better evaluate future conservation strategies that target the recovery of this species.

Keywords: boobook owl; conservation; monitoring; predation; reintroduction; translocation; wildlife health

Introduction

The monitoring of reintroduction programmes is important for determining their success and for informing future conservation actions (Fischer & Lindenmayer 2000). However, monitoring should be undertaken strategically (Ewen & Armstrong 2007) and be flexible enough to incorporate an adaptive management approach (Armstrong et al. 2007). Stitchbird (hihi: *Notiomystis cincta*) introductions in the 1990s (especially on Mokoia Island (38°05' S, 176°17' E) in 1994 and Tiritiri Matangi Island (36°36' S, 174°53' E) in 1995) are good examples of this; they were carefully monitored, with manipulations of certain key resources and management actions providing evidence for the relationship between these factors and population growth (Armstrong et al. 1999, 2007; Armstrong & Perrott 2000; Castro et al. 2003). In addition, the outcomes of the two translocations could be compared because of subtle differences in the reintroduction environments (e.g. Mokoia Island – henceforth 'Mokoia' – did not have bellbirds *Anthornis melanura*, one of the stitchbird's competitor species, while bellbirds were common on Tiritiri Matangi Island – henceforth 'Tiri'). Because subsequent population growth and adult survival of stitchbirds on Mokoia was poor relative to the Tiri population, this has provided an excellent opportunity to examine these differences to better understand what factors influence translocation success in this species (Armstrong & Ewen 2001; Armstrong et al. 2002; Ewen & Armstrong 2007).

The Mokoia Island stitchbirds

Forty stitchbirds (20 male, 20 female) were released on Mokoia Island in September 1994, with 17 males and 16 females surviving the first two months post-translocation. During the next seven years, the population never increased beyond this number (Armstrong et al. 2002, 2007) before their removal to Kapiti Island in 2002. This was in contrast to the growth of the stitchbird population on Tiri, which increased from six breeding females in 1996 to 42 in 2003 (Armstrong et al. 2002; Low et al. 2007). The key factor contributing to the differences in population growth between these two populations was annual adult survival probability (40% on Mokoia, 65% on Tiri;

Armstrong et al. 2002; Low & Pärt 2009). Supplementary feeding experiments undertaken from 1994 to 1997 on Mokoia showed that adult survival was low regardless of the intensity of supplementary feeding; suggesting factors other than food limitation were likely to be responsible for the differences in adult survival between the two islands (Armstrong & Perrott 2000; Armstrong & Ewen 2001; Armstrong et al. 2002).

During this time it was discovered that adult stitchbirds on Mokoia were unusually susceptible to aspergillosis, an often fatal fungal infection involving the respiratory system (Alley et al. 1999) and a disease commonly diagnosed in captive stitchbirds (Cork et al. 1999). Thus, it was suggested that the high rate of aspergillosis seen on Mokoia could be the factor responsible for the unexpectedly low rate of adult survival in this population (Armstrong & Perrott 2000). Perrott (2001) hypothesised that soil spore counts of *A. fumigatus*, which might give an indication of exposure to the disease agent, should be inversely related to adult survival rates in stitchbird populations. Soil spore counts are significantly higher on Mokoia than on Tiri (Perrott 2001; Armstrong et al. 2002), and based on this finding it has been frequently suggested that the difference in adult stitchbird survival rates between Mokoia and Tiri could be due to the higher *A. fumigatus* soil spore counts and/or higher rates of aspergillosis on Mokoia (Armstrong & Ewen 2001; Armstrong et al. 2002, 2007; Ewen & Armstrong 2007). Indeed, the current stitchbird recovery plan (Department of Conservation 2005) states that a necessary requirement for any future translocations is that there must be $<10^5$ *Aspergillus* spp. colony-forming-units per gram of soil at any proposed site.

However, an untested assumption underpins the idea that aspergillosis is the key underlying difference affecting survival rates in the two populations; namely, that mortality from aspergillosis was significantly higher on Mokoia than on Tiri. At no stage has the prevalence of aspergillosis in adult stitchbirds been compared between the two populations. Thus, it remains possible that aspergillosis is an equally important mortality factor on both islands. If so, then other factors should be examined when considering the observed differences in adult survival between these populations.

Aspergillosis in stitchbirds

During a 2-year study, 31 adult stitchbirds died on Mokoia, and the cause of death could be determined in 11 cases: six had aspergillosis, three were killed by moreporks (or ruru: *Ninox novaeseelandiae*), and two died from other causes (Alley et al. 1999). Of the other 20 birds that died during the study, eight showed evidence of a respiratory infection or voice change in the months prior to disappearance; however, the cause of death for these birds remains unknown (Alley et al. 1999; note that the percentages in fig. 1 of Alley et al. (1999) are incorrect in that the percentage of birds showing respiratory signs prior to death but without carcass recovery should be 26% (8 out of 31), not 44%; and the percentage of birds killed by avian predators should be 10% (3 out of 31) not 3%). Although it is probable that a proportion of these birds died from aspergillosis, it is also possible that a proportion died from a different respiratory ailment (as was the case for three stitchbirds recovered on Kapiti Island after showing similar symptoms; Cork et al. 1999), or from some other cause. If we assume that birds that did not display any respiratory dysfunction or voice change prior to disappearance were unlikely to have died from aspergillosis, then the proportion of adult mortalities that can be attributed to aspergillosis in this population ranges from 19% to 45% (cf. 67% in Castro et al. 2004).

No similar systematic study of the causes of adult mortality has been undertaken on Tiri. However, the cause of death was determined for 12 adult stitchbird carcasses that were retrieved opportunistically since 2000 (M. Low and M. Alley, unpubl. data). Two adult stitchbirds (a 1-year-old female and a 5-year-old male) were killed by a morepork; the other 10 adults without external injuries were sent to Massey University for post-mortem analysis. Three of these died from aspergillosis (25% of the total number of carcasses recovered). Because of the different collection techniques, factors influencing carcass recovery, and small sample sizes, it is difficult to compare the *Aspergillus*-induced mortality between the two populations. All that can be said with confidence is that on both islands the prevalence of aspergillosis in stitchbirds is higher than that expected in a free-living bird population (Orosz 2000).

Morepork predation

The diet of moreporks includes stitchbirds (Alley et al. 1999; Armstrong et al. 1999). Thus, following the successful fledging of a morepork chick from a known nest-site on Tiri in 2002, I assisted in removing the nest contents in an attempt to learn more about the dietary habits of the local breeding pair. This nest contained the remains of five bird species (reported in Fordham 2003): whitehead (*Mohoua albicilla*), red-crowned kakariki (*Cyanoramphus novaeseelandiae*), North Island robin (*Petroica longipes*), saddleback (*Philesturnus carunculatus*) and stitchbird. From the recovery of individually marked leg-bands, these originated from at least five stitchbirds: four juveniles taken prior to the breeding season, and a first-year breeding male that disappeared during the summer. While the morepork nest was still active I witnessed one of the morepork adults successfully catch and kill an adult North Island robin during daylight hours (1100) and return with it to the nest. This, in combination with the finding of two morepork-killed adult stitchbirds during the summer and the recovery of stitchbird bands from the nest, suggests that moreporks have the potential to increase mortality risk in local bird populations.

During the establishment of the Tiri stitchbird population (i.e. from 1995 to 2000) there were approximately 2–4 resident moreporks on the island (at an average density of 0.013 morepork ha⁻¹ across the island or 0.1 morepork ha⁻¹ within forest remnants). This can be contrasted with the estimate of 50–55 resident moreporks on Mokoia during stitchbird establishment (at an average density of 0.393 morepork ha⁻¹ across the island or 0.53 morepork ha⁻¹ within forest remnants; Stephenson et al. 1999). When one considers that the density of this predator was 5–30 times higher on the island with the lower annual adult stitchbird survival rate, the question arises whether this was a significant factor influencing the differences in population growth between Mokoia and Tiri. Although morepork

predation was definitively identified as the cause of death only in 10% of cases on Mokoia (versus 19% for aspergillosis; Alley et al. 1999), these data cannot be easily compared since the likelihood of carcass recovery probably differs for the two mortality factors. In 2002, when the remaining Mokoia stitchbirds were transferred to Kapiti Island, two out of the 10 adults fitted with transmitters were killed by moreporks within the first four weeks (Barr 2003).

Support for the idea that aspergillosis rates underlie population differences in adult survival has come from the finding that stitchbird population growth rates are negatively correlated with local *A. fumigatus* soil spore counts (Perrott 2001; Armstrong et al. 2002, 2007). However, the same correlation is also likely to apply to morepork density and stitchbird population growth.

Conclusion

Although there is evidence that death from aspergillosis is unusually high in stitchbirds when compared with other bird species, and that this is a significant cause of mortality (Alley et al. 1999; Cork et al. 1999), there is currently no direct evidence that the prevalence of this disease differs between stitchbird populations. Thus, it is premature to explain differences in adult survival between stitchbird populations in terms of differences in *A. fumigatus* infection rates, without also considering possible alternative explanations (e.g. differences in natural predator density).

Conservation managers often operate within a time frame where they are forced to make decisions based on 'best guesses' until evidence-based approaches can verify their decision or offer a better solution (i.e. adaptive management; Armstrong et al. 2007). Thus, it could be reasonably argued that the current recommendation of not permitting stitchbird translocations to sites with high *A. fumigatus* spore counts is sound, partly because it is easy to imagine a general benefit that arises from limiting the exposure of stitchbirds (the host) to *A. fumigatus* spores (the disease agent). However, it is also easy to imagine a situation where such a policy incurs a cost on the recovery of this species, by considering that aspergillosis plays little or no role in affecting differences in adult mortality rates between stitchbird populations. This could occur if the relationship between exposure to the disease agent (*A. fumigatus* spores) and development of the disease (aspergillosis) in free-living stitchbirds is asymptotic and approaches the asymptote at an exposure level below that currently found on Tiri. In such a situation, reducing exposure to *A. fumigatus* spores would bring little benefit because exposure is not correlated with the development of the disease (i.e. exposure is always at its maximum). Potential translocation sites could be evaluated incorrectly, by unfairly penalising those with high spore counts while not accounting for other factor(s) that could be responsible for the difference in adult mortality between Mokoia and Tiri.

Although aspergillosis and morepork predation probably both play some role in determining population differences in adult mortality rates, they may interact in unpredictable ways (e.g. aspergillosis may magnify the impact of morepork predation if the disease weakens adult stitchbirds and leaves them more vulnerable to predation) or have minor roles relative to other, unknown factors. Thus, we need to consider all plausible hypotheses for factors limiting populations so that we can better evaluate future conservation strategies that target the recovery of this species.

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