

Immediate and long-term effects of translocations on breeding success in Takahe *Porphyrio hochstetteri*

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Summary

Translocations of threatened species play an increasingly important role in conservation management. However, few studies have examined what effects, if any, the translocation process itself (i.e. catching, handling, confining, transferring and releasing an animal into an unfamiliar environment) has on subsequent breeding success. Takahe *Porphyrio hochstetteri* living on offshore “predator-free” islands in New Zealand are a model system for examining such effects because pre-breeding birds have been frequently translocated between established island populations before they pair up and breed at 2–3 years of age. We postulated that “translocated” breeders (i.e. breeders that had been raised on another island) would delay first breeding attempts and/or have lower reproductive success compared with “resident” birds (i.e. bred on the same island that they were raised). The results indicated that translocated birds did not delay breeding and had similar mean hatching and fledging success as resident pairs in their first breeding season and subsequent seasons combined. The results suggest that at least for large or long-lived birds such as Takahe, the effects of any stress from the translocation itself, or the release into an unfamiliar environment, might be either short-lived or not significant enough to hinder subsequent breeding success. We recommend that further research be carried out on other species to determine the baseline effects, if any, of translocations, so that they can be taken into account when considering other determinants of translocation success such as habitat suitability, number of individuals and timing of releases.

Introduction

Translocations, defined as the deliberate movement of a group of individuals from one place to another, play an integral part in the conservation strategy of many threatened birds (IUNC 1998, Soorae and Seddon 2001). There has been an increasing focus on understanding the causes of success or failure of translocations (Armstrong and McLean 1995, Armstrong *et al.* 1995). Some studies have attempted to assess translocation techniques such as hard versus soft release (e.g. Scott and Carpenter 1987, Castro *et al.* 1995, Lovegrove 1996). Others have focused on post-translocation survival (Kurzejeski and Root 1988, Musil *et al.* 1993, Armstrong *et al.* 1999, Armstrong and Ewen 2001), or whether survival and reproductive success are enhanced if translocated groups are made up of individuals that are familiar with one another (Armstrong 1995, Armstrong and Craig 1995).

In determining any direct effects of the translocation process itself, one might expect that catching, handling and transporting a pre-breeding bird, combined with releasing it into an unfamiliar environment, would impact negatively on its subsequent breeding success relative to an unmanipulated bird that had naturally dispersed from its natal environment, all else being equal. Alternatively, induced stress from the translocation itself might occur, but these effects could be short-lived. Hence the translocation *per se* may not affect a bird's ultimate reproductive performance by the time it settles onto a territory with a mate and breeds. These ideas are difficult to test because opportunities to compare breeding estimates between source and translocated populations are uncommon due to confounding factors. For example, direct comparisons of breeding success between birds in a source versus a newly translocated population can be confounded by differences in habitat, age of birds, population density, or presence/absence of predators.

The frequent translocation among and between established island populations of threatened Takahe *Porphyrio hochstetteri* (formerly *mantelli*; Trewick 1996) offers one such opportunity to examine the effects of translocation on breeding success. Takahe are large (~3 kg), flightless rails endemic to New Zealand. Thought to be extinct early last century, Takahe were 'rediscovered' in 1948 in the isolated Murchison Mountains, Fiordland, where there are now approximately 120 adult birds remaining (Lee and Jamieson 2001). During the late 1980s to early 1990s, a total of 25 adult and juvenile Takahe were translocated to four small offshore islands where introduced mammalian predators and competitors (e.g. mice, rats, stoats, sheep and cattle) had been removed or eradicated (Crouchley 1994, Bunin and Jamieson 1995). A stable breeding population of 5–7 pairs was eventually established on each island except Kapiti Island where the number of pairs has remained at two because of limited Takahe habitat (Ryan and Jamieson 1998, Jamieson and Ryan 2001).

As part of the management of these offshore island populations, juvenile or yearling Takahe are sometimes caught by hand or hand-nets and translocated to a different island either to balance sex ratios or to prevent mating between closely related individuals. Because the populations on each of the four islands consist of both "resident" breeders (i.e. those that bred on the same island on which they were raised) and "translocated" breeders (i.e. those that bred on an island other than the one on which they were raised), potential confounding variables between these two groups of birds, such as differences in habitat, population density and presence/absence of introduced predators, are not an issue. Thus the main difference in the development stage of resident and translocated breeders is that the latter group was placed in boxes, transferred to another island by boat or by helicopter, and released into an unfamiliar environment as pre-breeders. Takahe aggressively defend large territories (2.8–8.0 ha), which tend to be located near limited water sources such as small ponds (Ryan and Jamieson 1998). Therefore translocations might affect the time it takes for a young bird to obtain a breeding territory as well as its subsequent reproductive success. The overall aim of this paper was to compare age at first breeding and reproductive success between resident and translocated birds for their first breeding season and subsequent breeding seasons. The analysis was based on Takahe breeding records spanning 10 years (1991–2000).

Methods

Takahe have been translocated and established on four islands: Maud (available Takahe habitat: 57 ha), Mana (62 ha), Kapiti (43 ha), and Tiritiri Matangi (105 ha) (Ryan and Jamieson 1998). Details of island locations, translocation methods and number of founders are given in Crouchley (1994), Jamieson and Ryan (2000), and Jamieson *et al.* (2003). Island Takahe can be separated into two groups: original founders and island-hatched birds. In the analysis, we excluded any pairs consisting of at least one founding bird (26 pairs) because many of the founders had been raised in captive-rearing facilities and their ages at the time they were translocated ranged from pre-breeding juveniles to breeding adults. Hence the analysis focused exclusively on breeding birds that had been raised on the islands (16 pairs), some of which had been translocated to a different island as a pre-breeder. Translocated birds are either released in suitable habitat away from other territorial birds, or are initially penned in large enclosures for 2–3 days and fed supplementarily before the enclosure is opened. Because accurate records are unavailable of the release method used, and because all birds survived the initial release, we did not examine this aspect of the translocation.

Takahe on islands constitute closed populations, in which all active breeders are monitored. On each island, Department of Conservation staff locate nests, candle eggs during the incubation period, and remove non-developing eggs to determine fertility status. Nest contents are also checked at the end of the incubation period (~30 days) to record how many eggs hatched, and territories are subsequently visited at least every two weeks to monitor chick survival. Chicks that survive eight or more weeks were considered to have fledged.

Takahe typically breed as monogamous pairs, but where more than one male and/or female defended a breeding territory, such groups were eliminated from the analysis. There is no evidence of intraspecific brood parasitism (i.e. egg dumping) nor extra-pair paternity in Takahe (Lettink *et al.* 2002). Takahe start breeding from 2–3 years of age, are generally long-lived (> 12 years), and have low reproductive rates (Jamieson and Ryan 2001). There has been minimal change in the density of breeding pairs on each of the islands over the period covered by the analysis.

Pairs normally lay a clutch of two eggs, and can produce up to two replacement clutches if earlier clutches fail. However, they rarely fledge more than one chick per season, and many fail to fledge any chicks. Therefore, almost all of the variation in reproductive success among pairs across seasons is in the proportion of total eggs laid that hatch (hatching success) and the proportion of hatched eggs that fledge (fledging success). Because simple arcsine transformation of proportional data do not work as well at the extreme ends of the distribution (i.e. near 0 and 1), we used the following transformation:

$$p' = 1/2 [\arcsin \sqrt{(x/n + 1)} + \arcsin \sqrt{(x + 1/n + 1)}]$$

where X/n is the actual proportion (Zar 1996). Thus each breeding pair had one (transformed) value for hatching success and one for fledging success for the first breeding season and for all breeding seasons combined. Individual breeders occurred in the dataset only once. Statistical analyses were carried out using JMP v3.2 (SAS Institute 1997). All values given are means \pm S.E.

Results

Island-hatched breeders were divided into three groups: RESIDENT-RESIDENT pairs, both birds of a breeding pair were native to the island where they bred ($n = 8$); TRANSLOCATED-RESIDENT pairs, one bird of the pair had been translocated from another island before it commenced breeding ($n = 5$); and TRANSLOCATED-TRANSLOCATED, both birds had been translocated independently from another island before they paired and commenced breeding ($n = 3$). The main hypothesis we tested was whether RESIDENT-RESIDENT pairs would breed at an earlier age and/or have higher reproductive success than TRANSLOCATED-RESIDENT and TRANSLOCATED-TRANSLOCATED pairs for first breeding attempts, and possibly for subsequent breeding attempts as well.

All translocated birds attempted to breed (i.e. nested with at least one egg). There was no significant difference in the mean age of first breeding between resident males (2.9 ± 0.34 , $n = 10$) and translocated males (2.3 ± 0.44 , $n = 6$) (t -test, $t_{14} = 1.02$, $P = 0.33$), or between resident females (2.1 ± 0.20 , $n = 11$) and translocated females (2.6 ± 0.30 , $n = 5$) ($t_{14} = 1.43$, $P = 0.18$). There were also no significant differences in hatching and fledging success between RESIDENT-RESIDENT, RESIDENT-TRANSLOCATED and TRANSLOCATED-TRANSLOCATED pairs for both the first year of breeding (hatching, analysis of variance, $F_{2,13} = 1.78$, $P = 0.21$; fledging, $F_{2,7} = 1.11$, $P = 0.38$) and for all years combined (hatching, $F_{2,13} = 1.05$, $P = 0.38$; fledging, $F_{2,11} = 1.86$, $P = 0.20$). There was also no trend for RESIDENT-RESIDENT pairs to have higher mean breeding success than the other two groups (Figure 1).

To increase statistical power and to determine whether the additional factors of the island where breeding occurred and the year breeding commenced explained a significant proportion of the variation in reproductive success, we combined TRANSLOCATED-TRANSLOCATED and TRANSLOCATED-RESIDENT pairs (so that at least one member of a pair had been "TRANSLOCATED"), and compared them with "RESIDENT" pairs (neither member of a pair had been translocated). Neither island nor year breeding commenced, or whether one or both members of the pair had been translocated as pre-breeders, had a significant effect on hatching or fledging success (Table 1). Again, there was no trend for RESIDENT pairs to have higher mean breeding success than TRANSLOCATED pairs.

Discussion

Although Takahe are known to have high survival rates after translocation events (Bunin *et al.* 1997, Ryan and Jamieson 1998), we postulated that translocated birds might still delay first breeding and have reduced reproductive performance compared with resident birds. The results indicated that translocated birds did not delay first breeding compared with resident birds, and there were no significant differences in hatching and fledging success between resident and translocated breeders in their first breeding season, or when subsequent breeding seasons were combined. Although sample sizes were small, no trends were evident in the dataset that supported the hypothesis (e.g. translocated pairs actually had slightly higher hatching and fledging success than resident pairs).

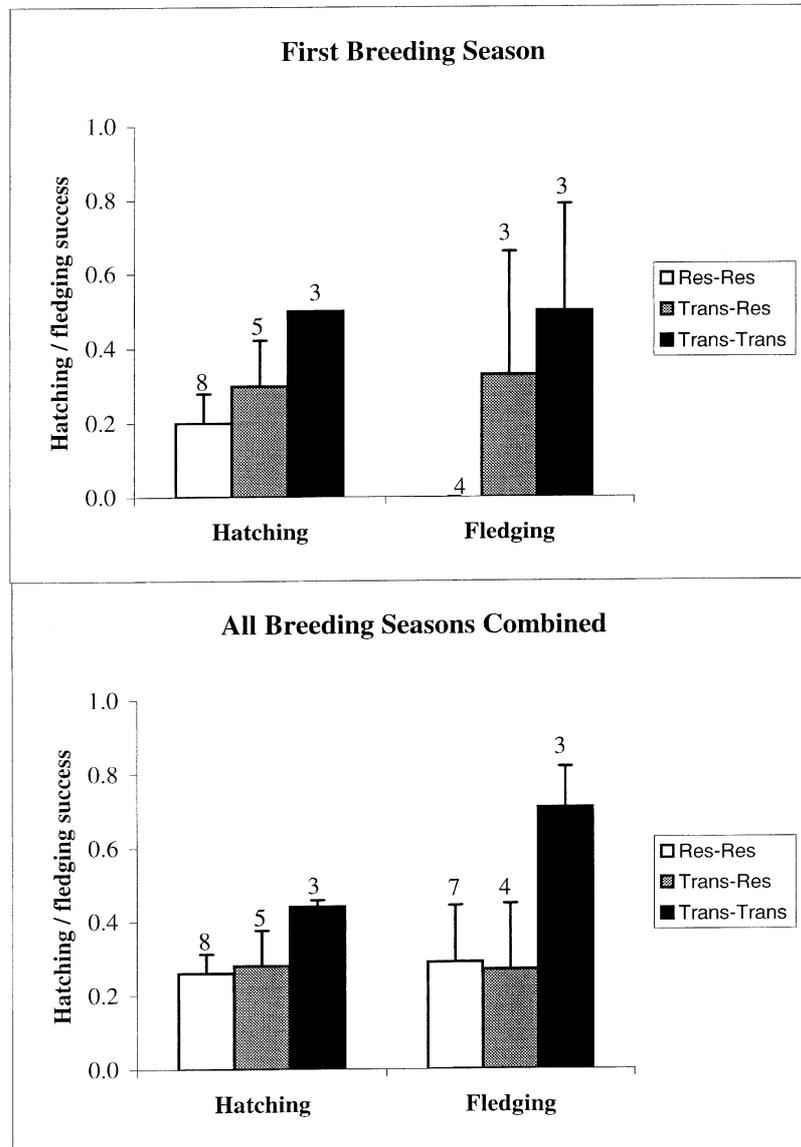


Figure 1. Comparison of mean hatching and fledging success between Resident-Resident pairs (both birds of a breeding pair were native to the island where they bred), Translocated-Resident pairs (one bird of the pair had been translocated from another island before it commenced breeding) and Translocated-Translocated pairs (both birds had been translocated independently from another island before they paired and commenced breeding), for Takahe breeding in their first season and all seasons combined from 1991 to 2000. Vertical bars indicate standard errors and numbers above bars are sample sizes.

Table 1. The results of a general linear model examining the effects of translocation (as pre-breeders), the island on which breeding occurred and the year breeding commenced, on hatching and fledging success for Takahe pairs breeding in their first season and all seasons combined from 1991 to 2000.

Response	Source	df	F	P
First breeding season				
Hatching	Translocation	1	0.64	0.44
	Island	3	0.23	0.87
	Year	1	0.46	0.51
Fledging	Translocation	1	0.33	0.60
	Island	3	2.44	0.20
	Year	1	2.34	0.20
All breeding seasons combined				
Hatching	Translocation	1	0.16	0.70
	Island	3	0.52	0.68
	Year	1	0.094	0.77
Fledging	Translocation	1	0.056	0.82
	Island	3	0.94	0.10
	Year	1	3.48	0.099

Any wild bird that is handled and kept in a confined space can presumably be stressed, and thus stress is an inherent part of any translocation. Increased stress levels associated with even a single capture and handling event are known to decrease growth rates of young Malleefowl *Leipoa ocellata*, and are thought to contribute to the chances of post-translocation failure (Sims 2001). Survival of birds immediately after a translocation event is often lower than subsequent survival (Kurzejeski and Root 1988, Musil *et al.* 1993, Armstrong and Ewen 2001). Even if the effects of increased stress from handling are short-lived, translocated birds still need to cope with an unfamiliar environment. Previous studies of birds have shown that reproductive output and survival of natural immigrants is often lower than that of resident-hatched individuals (Marr *et al.* 2002). A translocation effect was given as the best explanation for reduced breeding success of female New Zealand Robins *Petroica australis* in the first year after release, although there was no effect over the longer term (Armstrong and Ewen 2001).

The results from this study indicate that, at least for Takahe, the effects of any stress from the translocation itself were either short-lived or not significant enough to hinder breeding success by their first season. It appears that young birds translocated to an unfamiliar island can settle and eventually establish themselves as breeders as successfully as resident birds do after leaving their natal territory. From a management perspective, the transfer of Takahe between islands does not seem to have any detrimental effect and may be beneficial by helping to reduce the frequency of close inbreeding. Although closely related pairs do not have significantly lower hatching and fledging success than unrelated pairs (based on long-term pedigree data), inbred females (but not males) do have significantly lower fledging success than non-inbred females (Jamieson *et al.* 2003). Four of the eight females of the resident pairs in the current study were inbred, compared with one of eight of the translocated pairs. However, a reanalysis of the dataset did not reveal any significant effect of inbreeding on reproductive success.

We conclude that for relatively large or long-lived birds such as Takahe, translocation events involving pre-breeders might not have any lasting effects on subsequent breeding success. We recommend that further research be carried out on other species to determine if there are any baseline effects associated with the handling, confinement and transfer of birds as well as their release into unfamiliar environments, which could negatively influence subsequent survival and breeding success. The potential effects of the translocation itself, if they exist, should be taken into account in addition to the factors that are normally considered important determinants of translocation success such as habitat suitability, number of individuals and timing of the release. We believe that our experimental measurement of the direct effects of translocation on breeding success in Takahe will provide a useful template for further research in this area.

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