Variation in inter-territory reproductive success of takahe introduced to predator-free islands

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CONTENTS

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ABSTRACT

The endangered New Zealand flightless rail the takahe (*Porphyrio hochstetteri*) has been introduced to four island refuges. Takahe have increased in numbers on these islands, but population growth has been slower than expected due to poor hatching and fledging success. Takahe are strongly territorial, and appear to favour specific areas on each island in which to breed. The aim of this study was to compare fledging success among territories on each of the four islands to determine if inter-territorial differences existed. Only Maud Island showed significant variation in fledging success among territories. For Kapiti and Mana Islands, more of the variation in fledging success was explained by differences among pairs than territories. Overall, reproductive success on most territories was low, with only 7 of 23 territories having a mean fledging rate greater than 60%. Because we cannot predict what is likely to be a good territory from one year to the next, we conclude that differences in territory quality of presently utilised nesting areas may not be great enough on any of the islands except Maud to warrant management measures to potentially improve some of these sites.

Keywords: takahe, island refuges, territory, breeding success, habitat quality.

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1. Introduction

The takahe (*Porphyrio hochstetteri*) is a large flightless rail that is endemic to New Zealand. Its last remaining natural population is in Fiordland, where it currently (2002) numbers around 140 (Department of Conservation, unpubl. data). As part of the effort to save this species from extinction, takahe were translocated during the 1980s and 1990s to four islands (Maud, Mana, Kapiti and Tiritiri Matangi Islands, Fig. 1) free of introduced mammalian predators and grazers. The released birds have bred successfully and the number of takahe on islands has gradually increased, but growth in numbers has been slower than expected due to low hatching and fledging success (Jamieson & Ryan 2000). Several studies have attempted to determine the cause or causes of this pattern, including aspects of takahe diet and incubation behaviour (Jamieson & Ryan 1999; Jamieson & Easton 2002), inbreeding (Jamieson & Ryan 2000; Jamieson et al. 2003) and the effects of translocations themselves (Jamieson & Wilson 2003).

Takahe are strongly territorial, and appear to favour specific areas on each island in which to nest and raise their offspring. A high frequency of territorial aggression in the breeding season is common on the islands, and may indicate that the number of suitable breeding sites is limited. If this is so, then takahe that nest in more suitable areas may be more successful than those nesting in poorer quality areas. Therefore, over a number of seasons some territories would, presumably, have higher average fledging rates than others. If it were known that some territories were better than others, then these better territories could be characterised in terms of vegetation composition and structure, topography, water availability etc. This knowledge could then be used to 'upgrade' poorer quality takahe nesting areas, or more accurately assess the suitability of new areas to which takahe could be introduced.

The present study uses information gathered by Department of Conservation (DOC) workers on the four islands to compare fledging success between the territories on each of the islands. From this, any inter-territorial differences are determined.

2. Methods

Small numbers of juvenile and / or adult takahe were released on four offshore islands between 1984 and 1991 (for more detail, see Jamieson et al. 2003), with first breeding attempts recorded on Maud I. in 1986, Mana I. in 1988, Kapiti I. in 1989 and Tiritiri Matangi I. in 1992 (Fig. 1). DOC staff began to record nest locations of breeding takahe (initially with a site description but later using a grid-reference system) on Kapiti in 1992, Mana in 1993, and Maud and Tiritiri Matangi in 1995. No nest site locations were available for Maud in 1998. For the purposes of this study, we refer to a breeding pair's territory in relation to the location of its

Figure 1. Maps showing the locations of takahe breeding territories (dashed lines) on each of four island populations from 1992 to 2000. Only territories with nest site data from at least three seasons were included in the analysis (closed circles); nest sites in areas that were defended less regularly (open circles) were not included in the analysis. Shaded areas indicate areas of forest or regenerating bush.

nest site. We mapped the nest site locations recorded each year (up to the 2000/01 breeding season) and then delineated 'territories' in relation to clusters of nest sites in different parts of each of the islands (Fig. 1). Takahe breed in pairs or small groups and defend large areas around their nest sites (3–8 ha: Ryan & Jamieson 1998; 2–17 ha: Barber & Craig 2003) and tend to nest in the same area from one season to the next. Therefore, territories were relatively easy to delineate, even when pairs nested in close proximity to each other within the same year (e.g. Mana I., Fig. 1). Only territories for which there were at least three seasons' data were included in the analysis. Nest sites / territories of two pairs, for which the breeding male was thought to be sterile, were excluded.

On each of the islands, DOC staff locate and inspect takahe nests several times over the incubation period, during which eggs are counted, candled and non-developing eggs removed to encourage re-nesting. Nest contents are checked at the end of the incubation period to record how many eggs hatched, and territories are visited at least every 2 weeks to monitor chick survival. A chick that survives 8 or more weeks is considered fledged and is referred to as a juvenile.

Takahe females 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, whether breeding takahe nesting within a particular territory succeeded or failed (denoted '1' or '0', respectively) to fledge one or more chicks per season was used as our measure of a territory's productivity or fledging success. These data were modelled with a logistic regression using a log-likelihood ratio chi-square. A breeding pair / group tended to use the same territory over several consecutive years, although not invariably so. Variation in fledging success between territories (a fixed factor) was of primary interest, but pairs were included as a random-effects factor nested within territory, to account for some within-group variability (Zar 1996: p. 307). Year was also included as a co-variable to account for variation across years, with each island analysed separately.

3. Results and Discussion

Some islands showed greater variation in fledging success among territories (Maud I., Tiritiri Matangi I.) than others (Mana I., Kapiti I.) (Fig. 2). Mean fledging success on territories was confounded by mean fledging success of certain pairs using those territories. Nevertheless, most territories had data from more than one pair / group of takahe over the period of the analysis, and when individual pairs were taken into account, differences between territories did not explain a significant proportion of the variation in fledging rates for three of the four islands. For Maud I. only did territory have a significant effect, while significantly more variation could be explained by differences in fledging success among pairs than by territories on Kapiti and Mana Is (Table 1).

There were few trends in terms of neighbouring territories in similar types of habitat being more successful than territories in other parts of the island, nor was there any evidence that pairs on more isolated territories and presumably with a lower frequency of territorial fighting, have higher fledging success. For example, territories around the Lodge and South Fort Road on Maud I. were adjacent to each other in similar types of habitat (Fig. 1), but had substantially different fledging rates (Fig. 2). On Mana I., territories located around the lower wetlands (Generator, House, House Valley and Upper Pond) had mean fledging rates that were no higher or lower than territories located in drier parts of the islands (Figs 1 and 2). On Tiritiri Matangi, takahe utilising Wharf Road, Cable Track, and Bunkhouse all had relatively high fledging rates, whereas those on

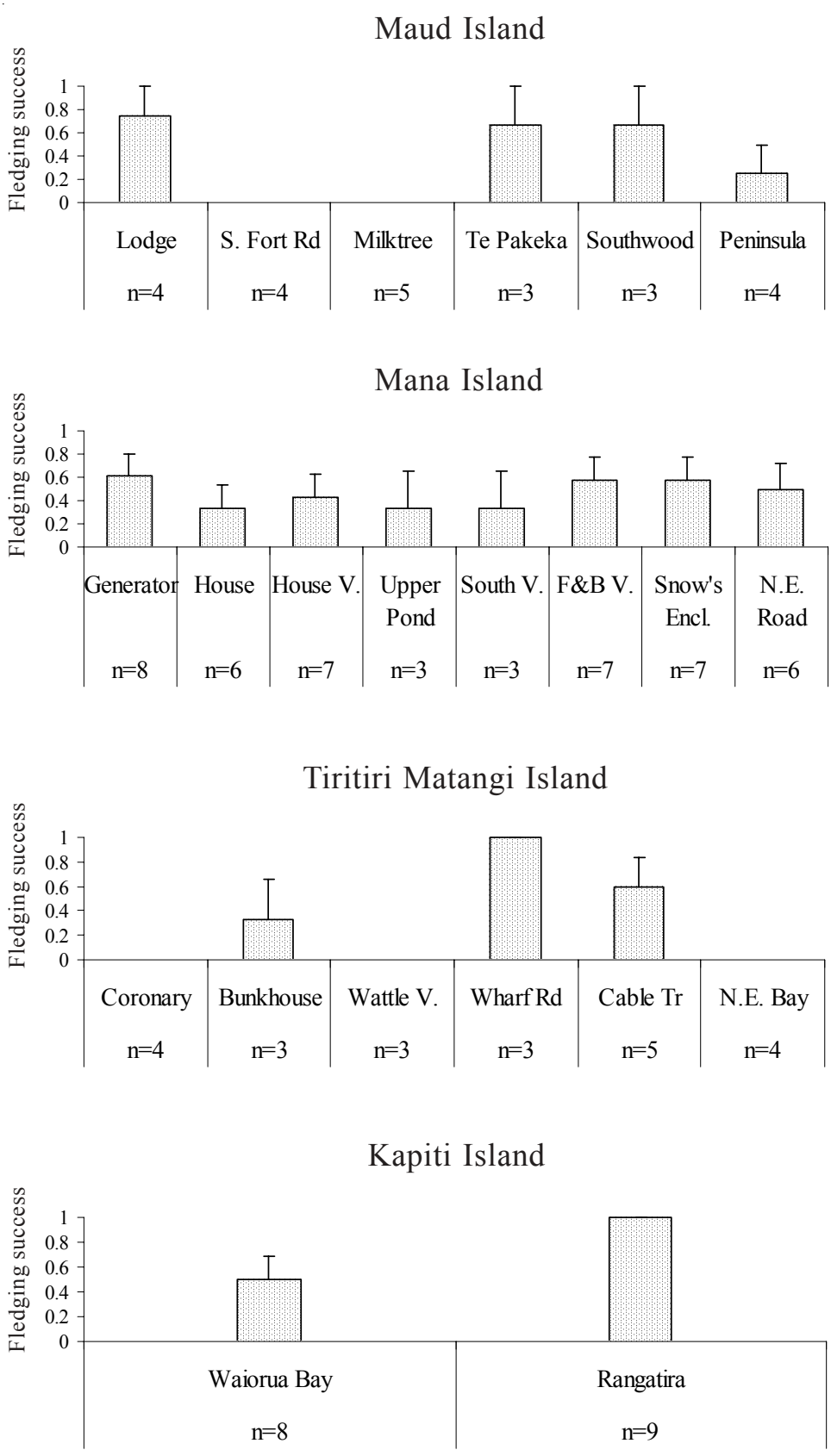

Figure 2. Mean fledging success, as defined by the average of successful (1) and failed (0) attempts to fledge at least one offspring per season, for various takahe territories on each of four island populations from 1992 to 2000. Vertical bars indicate standard errors and *n* values indicate number of seasons' data. Only territories for which there were three or more seasons' data were included.

Coronary, Wattle Valley and North East Bay were all relatively low (Figs. 1 and 2). Both territories on Kapiti had reasonably high fledging rates. Overall, reproductive success on most territories was low, with only 7 of 23 territories having a mean fledging success greater than 60% (Fig. 2).

In a recent (2002/03) takahe supplementary feeding and habitat study on Maud I., King (2003) noted that the breeding pair using the South Fort Road Territory had significantly more palatable plant species and significantly less unpalatable plant species than a pair located on the Peninsula Territory, and thus were less dependent on supplementary food for feeding their chicks. Our results showed that the South Fort Road Territory failed to fledge a chick over the four years of our analysis (Fig. 2). The poor fledging success was primarily a consequence of poor egg fertility and hatchability in three of the four years' data. Whether territory quality affects fertility or egg hatchability in island takahe is unknown. However, using a coarse productivity measure such as whether or not a pair fledged one or more chicks could be inappropriate if one was trying to detect differences in territory quality that specifically affected chick rearing success. By only including pairs that hatched at least one chick, eight territories in total (South Fort Road and Te Pakeka on Maud I.; South Valley and Upper Pond on Mana I.; Coronary, Bunkhouse, Wattle Valley and N.E. Bay on Tiritiri Matangi) get omitted from the analysis because they had less than three years of data. Nevertheless, the reanalysis renders similar results to those above in that only Maud I. showed significant variation in fledging success among territories ($\chi^2 = 10.6$, d.f. = 3, P = 0.01).

The negative results found for three of the four islands do not mean that territory or habitat quality has no effect on takahe breeding success. It is possible, for example, that the general differences between Fiordland and island habitats or environmental conditions are large enough to mask any smaller differences within islands. Furthermore, large areas on each of the islands are not utilised by any breeding takahe, indicating that they may be of poor quality or lacking essential resources such as sufficient standing water. Island managers are already fully aware of where these areas are and how they

TABLE 1. RESULTS OF LOGISTIC REGRESSION ON FLEDGING SUCCESS FOR EACH OF THE FOUR ISLANDS WITH TERRITORY, PAIRS (NESTED WITHIN TERRITORY) AND YEAR (CO-VARIABLE) AS SOURCES OF VARIATION.

	SOURCE	DF	χ^2	P
Maud	Territory	5	18.34	0.0025
	Pair	6	4.14	0.66
	Year	1	4.82	0.03
Mana	Territory	7	5.14	0.64
	Pair	15	28.53	0.02
	Year	1	3.32	0.07
Tiritiri Matangi	Territory	5	7.53	0.18
	Pair	5	6.17	0.29
	Year	1	0.94	0.33
Kapiti	Territory	1	0.001	0.99
	Pair	3	8.75	0.03
	Year	1	2.77	0.10

could be modified to improve takahe nesting habitat. What our results indicate is that differences in territory quality of presently utilised nesting areas may not be great enough on any of the islands except Maud to warrant management measures to potentially improve some of these sites. In other words, we cannot predict from the current dataset, what is likely to be a good territory from one year to the next, with success depending, to a certain extent, on which pairs nest on which territories.

Another interpretation of these data is possible, in conjunction with other studies on factors affecting reproductive success of island takahe (Bunin et al. 1997; Small 1999; Jamieson & Ryan 2000, 2001; Jamieson & Easton 2002; Jamieson et al. 2003; Jamieson & Wilson 2003); differences in habitat quality—at least for Mana, Tiritiri Matangi and Kapiti Is—could be eliminated for the time being as a significant factor in explaining why breeding success of island takahe is so low. Although the present study did not take into account possible broader habitat quality differences baetween islands, previous analyses have indicated that islands as a factor is a poor predictor of takahe reproductive success (Jamieson & Ryan 1999; Jamieson et al. 2003).

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