

# Factors affecting the survival of founding individuals in translocated New Zealand Saddlebacks *Philesturnus carunculatus*

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Successful founders of new populations may represent a non-random sample of potential founding individuals. Using a recent Saddleback *Philesturnus carunculatus* translocation as a natural experiment, we related morphology, parasite load and genetic variation of translocated individuals to subsequent survivorship to assess the traits of successful founders. We also included capture location and holding time in our models to account for variables particular to translocations. Generalized linear model results suggest that, in addition to capture location, poor body condition (males) and the presence of ectoparasites (females) significantly reduced survivorship. Despite recent claims in the literature, we found no evidence that genetic variation was associated with survivorship or parasite load.

Survivorship of individuals during selection and founding events typically relates to individual characteristics. Earlier studies focused on associations of morphological characteristics with survivorship, but with the advent of molecular methods, genetic variation was directly and indirectly linked to survivorship, the latter through its association with pathogen load (Coltman *et al.* 1999, Hansson *et al.* 2001, Acevedo-Whitehouse *et al.* 2003, 2006). The relationship between morphology and individual survivorship usually depends on selection pressure; for instance, a broad range of morphologies might survive stable environmental conditions but only a subset will survive stressful periods such as drought or cold weather (Price *et al.* 1984, Hairston & Walton 1986, Seeley 1986, Brown & Brown 1998, Shine *et al.* 2001).

The association between genetic variation, pathogens and survivorship is more complex. Greater genetic variation is directly associated with higher survivorship in Great Reed Warbler *Acrocephalus arundinaceus* (Hansson *et al.* 2001) and Harbour Seal *Phoca vitulina* recruits (Coltman *et al.* 1998) but, more commonly, mortality caused by pathogens is associated with reduced genetic variation (Paterson *et al.* 1998,

Coltman *et al.* 1999, Langefors *et al.* 2001, Arkush *et al.* 2002, Acevedo-Whitehouse *et al.* 2003, Pearman & Garner 2005, Whiteman *et al.* 2006).

Like survivorship during selection events, survivorship during founding events may represent a non-random sample of the original population, perhaps as a consequence of specific attributes such as body size, pathogen load, genetic variation or interactions among them. Although many avian studies have examined morphological and genetic differences between source and newly established populations (Baker & Moeed 1987, Merilä *et al.* 1996), surprisingly few have addressed the attributes of successful founding individuals. The attributes of successful founder individuals are largely unknown because recently founded populations are usually studied after the population has become established, by which time no information on the individual characteristics of potential founders is available. To date, the only avian study that has fully documented the individual attributes of successful founders discovered that the birds that survived and bred in the first breeding season were significantly larger and more genetically variable than the non-survivors/non-breeders (Grant *et al.* 2001). Identifying individual attributes that ultimately affect survivorship is important because it may clarify the evolutionary potential of a species, including the likelihood of successful survivorship and establishment of new populations.

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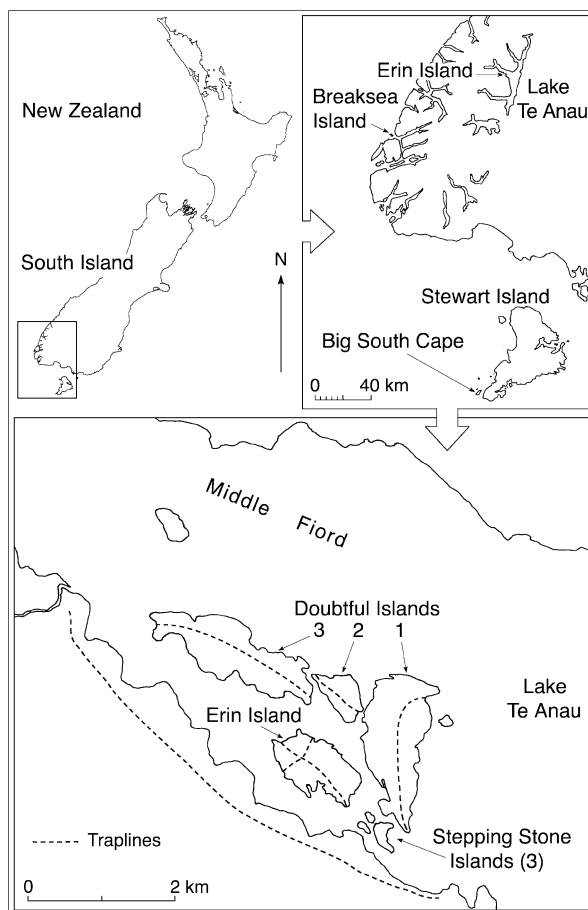
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In New Zealand, endangered species are frequently translocated to offshore island refuges free of introduced predators and pests; this practice provides a unique opportunity to undertake a natural experiment that examines the traits of successful founders. Characteristics such as size, parasite load and genetic variation can be measured for all individuals prior to the translocation and then related to subsequent survivorship by monitoring the population as it establishes. South Island Saddlebacks *Philesturnus carunculatus carunculatus* have been frequently translocated to island refuges because of their susceptibility to predation by introduced mammals, particularly rats (Lovegrove 1996, Hooson & Jamieson 2003).

South Island Saddlebacks are endemic to New Zealand, belonging to the family Callaeidae. They are non-migratory, territorial, medium-sized passerines (males 80 g, females 70 g) with poor flying ability, feeding chiefly on invertebrates (Higgins *et al.* 2006). The birds locate prey from the forest floor by rummaging in litter and digging into rotting logs, and from standing trees by prising off bark and inserting their chisel-shaped bills into crevices on the trunks and branches (Higgins *et al.* 2006). They may also feed on a variety of fruits and nectar (Higgins *et al.* 2006). On newly established islands, Saddlebacks show density-dependent growth and may produce up to three broods between September and February (Armstrong *et al.* 2005).

South Island Saddleback populations declined drastically following the introduction to New Zealand of exotic predators such as Stoats *Mustela erminea* and rats (*Rattus rattus*, *R. norvegicus*, *R. exulans*), until finally, the birds were found only on Big South Cape Island (Fig. 1). When rats invaded Big South Cape Island in the mid-1960s, just 36 birds were rescued and translocated to two nearby rat-free islands where they and their descendants were used to propagate the subspecies via a series of translocations (Hooson & Jamieson 2003).

With a current population of approximately 1200 birds on 15 island refuges, South Island Saddlebacks are now considered secure (Hooson & Jamieson 2003), but their population size is limited by the small number of suitable offshore islands that are beyond the swimming range of introduced predators. The remoteness of many of these offshore islands also limits the ability of the public to view and experience New Zealand's threatened native fauna. Consequently, New Zealand's Department of Conservation (DOC) is testing whether inshore islands close to the mainland can be used as translocation sites. The suitability



**Figure 1.** Map of Erin Island and its relation to Breaksea and Stewart Islands off South Island, New Zealand. An additional four Stoat traps are located on the Stepping Stone Islands (two on the largest islet, one on each of the smaller islets).

of inshore islands will largely depend on whether they can be kept free of predators following eradication and/or whether Saddlebacks can survive occasional predator re-invasions. If so, a large number of sites with suitable habitat then become available for future translocations, which would promote further population growth and potentially promote conservation values by allowing easier public access to island refuges.

As a part of their inshore island re-invasion study, DOC chose a small cluster of islands in the Middle Fiord of Lake Te Anau (Fig. 1). All resident Stoats were first eradicated using stoat kill-traps established along permanent trap lines on the islands and, to inhibit re-invasion, along ~6.5 km of the adjacent mainland (Fig. 1). It was subsequently discovered that the Doubtful Islands, but not Erin Island, also

had a resident population of Pacific Rats or Kiore (*R. exulans*). The Doubtful Islands are within swimming range of rats because they can use the Stepping Stone Islands to transit (Fig. 1), but Erin Island is more isolated and beyond their swimming range (M. Willans pers. comm.). Consequently, Erin Island was chosen for the re-introduction of Saddlebacks and the birds were translocated in September 2003 and April 2004.

Erin Island (67 ha) is characterized by Mountain Beech *Nothofagus solandri*, Kamahi *Weinmannia racemosa* and mossy ground-cover on its small hills, and Mountain Beech, mixed broadleaf, tree fern (*Cyathea smithii*, *Dicksonia fibrosa*) and Supple Jack *Ripogonum scandens* in its low, moist, areas. Saddlebacks were sourced for translocation from Breaksea Island (170 ha; Fig. 1), Fiordland National Park, itself established with translocated Saddlebacks in 1992 (Rasch & McClelland 1993). Breaksea Island is steeper and much more rugged than Erin Island, but is similarly vegetated with Mountain Beech and a mixed broadleaf forest of Southern Rata *Metrosideros umbellata* and Kamahi.

Ultimately, both translocations failed. Birds that were translocated in September 2003 and survived the establishment phase (first 2 weeks following translocation) were consistently present and completed a nesting cycle by 14 February 2004. When a follow-up translocation was carried out in April 2004 to augment the existing population, the Saddlebacks from the earlier September translocation had all disappeared. A similar pattern occurred for the birds translocated in April. Although present continuously and having bred successfully between April 2004 and February 2006, no Saddlebacks were present in June 2006. It is unclear why Saddlebacks from both translocations all suddenly vanished at approximately the same time of year. One possibility is predation by a family of New Zealand Falcons *Falco novaeseelandiae*, which were not previously seen on Erin Island but were present on the island in April 2004 and flew in to playback of Saddleback calls. Alternatively, a Stoat may have swum over from the mainland, wiped out the Saddleback population, and returned to the mainland without being caught in the stoat traps.

Whatever the cause of the sudden demise of the growing Saddleback population, data from these translocations offer a unique opportunity not only to improve translocation success itself but also to examine the evolutionary basis for establishment of successful new colonies or populations. We examined the individual attributes of successful founders during

the establishment phase of this island re-introduction by measuring morphological characteristics, parasite load and genetic variation of translocated Saddlebacks and relating it to individual survivorship.

## METHODS

### Saddleback capture and measurement

Saddlebacks were captured in mist-nets between 10–12 September 2003 ( $n = 20$  birds) and 31 March to 6 April 2004 ( $n = 26$  birds) on Breaksea Island. A banding station was established at the island's research hut where all birds were brought following capture to band individuals with unique colour bands, measure them and collect blood samples. Wing length (maximum unflattened chord) was measured with a stopped wing ruler to the nearest  $\pm 1$  mm and birds were weighed to the nearest  $\pm 1$  g with spring scales. Tarsus length was measured using the distance between the intra-articular notch at the proximal end of the tarsometatarsus and the middle of the mid-tarsal articulation. Two tarsus measurements were taken from each side of the body and averaged. Tarsus length, bill length (exposed culmen), bill depth (at nares) and bill width (at nares) were measured with Vernier callipers to the nearest  $\pm 0.1$  mm. All measurements were made by S.S.T., and therefore no correction factors for multiple measurers were necessary (Grant & Grant 1995). Saddleback age was determined by differences in plumage between adult and yearling/hatch-year birds (Higgins *et al.* 2006).

A small blood sample (100  $\mu$ L) was taken from the brachial vein of each bird to assess blood parasite load (analysed by K. Hale, Canterbury University, Christchurch) and to genotype DNA. Birds were visually inspected for ectoparasites, including feather mites (Arachnida), lice (Phthiraptera) and hippoboscids (Diptera: Hippoboscidae). Following this process, Saddlebacks were released into an aviary (approx.  $2 \times 4 \times 7$  m) where they were provided with food (fruit, mealworms, whole kernel corn, honey water, and the protein drink Complan<sup>TM</sup>), water, and fresh vegetation for roosting and shelter. Saddlebacks were held for up to 5 days before translocation. Birds were re-captured in the aviary and translocated on 12 September 2003 and 6 April 2004 in wooden transfer boxes by helicopter to Erin Island approximately 90 km or 30 min away from Breaksea Island (Fig. 1). Birds were released from their transfer boxes immediately following arrival at the island and

monitoring began 4 days after the first translocation and 1 day after the second translocation.

### Survivorship

We were interested in survivorship during the release and initial establishment phase, which we defined as the first 2 weeks following translocation. All post-release mortality occurred during this period (see Results). Erin Island and surrounding areas were surveyed intensely during the first 2 weeks after release and then weekly during the breeding season, which occurs from September to February. We conducted regular ground surveys along the two Stoat traplines (Fig. 1), along 12 flagged transect lines 100 m apart and covering the entire island, by searches of moist areas where the birds were usually found, and with boat trips around the island. Audio playback was used occasionally during ground surveys and always from the boat. Saddlebacks are noisy, curious and easily located, allowing us to obtain accurate survival estimates of the founding individuals. Erin Island is separated by approximately 300 m of open water from the mainland and 160 m from the next nearest island (Doubtful Island 1; Fig. 1). Conceivably, Saddlebacks could disperse from Erin Island and fly to the mainland (although the mainland is 50 m further away than the maximum recorded dispersal distance; Newman 1980) or to any of the three Doubtful Islands via Doubtful Island 1 (Fig. 1). However, we never sighted Saddlebacks during a survey of the mainland Stoat trapline a week after each translocation (using audio playback) or during maintenance of the mainland Stoat trapline, which is surveyed once every 3 months by staff that recognize Saddlebacks and their calls. All Doubtful Islands were monitored regularly and extensively using ground surveys for a concurrent New Zealand Robin *Petroica australis* study and were surveyed for Saddlebacks once a month by boat using audio playback. Two unpaired Saddlebacks dispersed to Doubtful Island 1 approximately 3 and 5.5 months after the first translocation, possibly seeking mates. Therefore, our definition of survival is any bird that was re-sighted at any time after the release with the assumption that dispersal to the mainland did not occur and dispersal to neighbouring islands was detected. Birds present on Erin Island were usually detected during the weekly surveys (i.e. Saddlebacks were never re-sighted after going undetected for several weeks), and therefore non-survivors were considered to be dead on the day following the last day sighted.

### Genetic analyses

Saddleback DNA was extracted from blood with proteinase K (40 µg) in a Chelex® 100 Resin solution (50 mg/mL) and individuals were genotyped at seven polymorphic loci: Ase18, CK5A4B, Hrµ6, K13/14, Pca08, Pca15 and Pgm 1 (Primmer *et al.* 1995, Tarr & Fleischer 1998, Hudson 1999, Richardson *et al.* 2000, Dowling *et al.* 2003, Lambert *et al.* 2005). PCR reactions were 10 µL in volume and contained 1 µL DNA, 0.5 µM of each primer, 0.8 µM dNTP, 1 µL buffer, 0.5 U *Taq* DNA polymerase (AB Gene), an optimized concentration of MgCl<sub>2</sub>, and for primers that produced shadow bands, 2.2 µL betaine (5.0 M) and 0.2 µL DMSO. The PCR profile consisted of denaturation at 92 °C for 3 min, followed by 35 cycles at annealing temperature for 30 s, 72 °C for 1 min and 92 °C for 1 min, followed by one final annealing step for 30 s and extension at 72 °C for 4 min. DNA fragments were visualized on 6–10% vertical, non-denaturing or 6% denaturing polyacrylamide gels. For denaturing gels, 10 pmol of reverse primers was radioactively end-labelled in 10-µL reaction volumes containing 5 µCi of [<sup>32</sup>P-ATP], 2.5 U T4 polynucleotide kinase (Bioline), and 1× kinase buffer (Bioline). Individuals expressing all known alleles were run on every gel as size standards, and on non-denaturing gels molecular rulers (10- or 20-bp ladders) were used as additional size standards. To measure genetic variation within an individual, we used individual multilocus heterozygosity (MLH), which was calculated as the proportion of heterozygous loci over the total number of loci for each individual (Coltman & Slate 2003).

### Statistical analysis

We used generalized linear models with a binomial distribution and logit link to examine survivorship (the response variable) and individual MLH (continuous), ectoparasite presence (categorical: present or absent), and body measurements/body condition index (continuous) as explanatory variables. No blood parasites were detected in the samples collected (K. Hale pers. comm.), so we did not include this variable in the analysis. Body measurements included tarsus length, wing length, body mass, and bill length, depth, width and volume (approximated as the volume of a pyramid using bill length × bill depth × bill width × 1/3). Body condition was an index given by body mass/tarsus length (Brown & Brown 1998).

Besides our variables of interest, other variables may also have an effect on survivorship. We initially examined capture period (September or April), bird age (adult or yearling/hatch year) and variables specific to the translocations (capture location and time held in the aviary) using the full dataset ( $n = 46$ ). Capture location had two categories: birds caught at the hut (nets within 20 m of the hut) or birds caught away from the hut (nets approximately 1 h away from the hut by foot). Time held had two categories according to the number of days a bird was held in the aviary prior to translocation:  $\leq 2$  days and  $> 2$  days. In the preliminary analysis, capture period, age and time held in the aviary did not significantly affect survivorship (capture period:  $\chi^2 = 1.63$ ,  $df = 1$ ,  $P = 0.20$ ; age:  $\chi^2 = 1.06$ ,  $df = 1$ ,  $P = 0.30$ ; time held in aviary:  $\chi^2 = 0.03$ ,  $df = 1$ ,  $P = 0.87$ ) and so were eliminated to reduce the number of variables in our main analyses. Capture location was associated with survivorship. Saddlebacks captured away from the hut were held longer during mist-netting and transportation to the banding station (approximately 2 h) and had higher mortality than Saddlebacks captured in mist-nets adjacent to the hut ( $\chi^2 = 11.9$ ,  $df = 1$ ,  $P = 0.0006$ ); therefore, we excluded all birds captured away from the hut ( $n = 21/46$ ) from the remainder of the analyses to examine the effect of our chosen variables.

For our variables of interest, we used separate generalized linear models for each sex because morphology is strongly correlated to sex in Saddlebacks (Taylor & Jamieson in press). The sex of the captured birds was unknown, so we first classified individuals as males or females with a discriminant function analysis using mean tarsus length (Taylor & Jamieson in press).

The best model for survivorship was chosen based on the Akaike Information Criterion (AIC) where lower AIC scores indicate better models. AIC was calculated by the following formula:  $AIC = -2 \times \log \text{likelihood (fitted model)} + 2 \times p$ , where  $p$  = the number of parameters in the model. The combination of a large number of variables and a small dataset ( $n = 10$  males,  $n = 15$  females) meant that full models would not converge, so single variable models were investigated first. The single variable model with the lowest AIC score was used as a basis to build the model and additional variables were added if they were significant (as single variable models) and had an AIC score that did not differ by more than 4 from the best single variable model (Akaike 1992).

Genetic variation could affect survival either directly or indirectly via ectoparasite load. To examine the association of genetic variation with survivorship

via parasite load, we used generalized linear models for each sex with ectoparasite presence/absence as the response variable and MLH as the explanatory variable. All analyses were performed with JMP 6.0 with significance set to  $\alpha = 0.05$ .

## RESULTS

Eight of 46 Saddlebacks died on Breaksea Island during the capture period, two before the first transfer and six before the second transfer. All transferred birds ( $n = 38$ ) were successfully released on Erin Island. Post-release mortality (including birds captured away from the hut; see Methods) occurred immediately or within days of the releases; 19 of the 22 birds that died were never resighted after the releases and the other three birds only survived 1, 7 and 11 days following the releases. A total of 16 birds (five males and 11 females) survived the transfers and were observed repeatedly over 5 months (two females captured away from the hut survived but were not included in the analyses: see Methods)

Birds captured away from the hut were significantly less likely to survive translocations ( $\chi^2 = 11.9$ ,  $df = 1$ ,  $P = 0.0006$ ). After removing these data (to examine the effect of individual characteristics on survival), separate models for each sex were used to account for significant differences in morphology between males and females. In males ( $n = 10$ ), the only significant single variable model explaining survivorship featured body condition (Table 1). This model had a low AIC score, was significant ( $\chi^2 = 4.64$ ,  $df = 1$ ,  $P = 0.03$ ) and had a good fit (Pearson  $\chi^2 = 9.4$ ,  $df = 8$ ,  $P = 0.31$ ) with no evidence for overdispersion. Males that were in better condition had a higher probability of survival compared with males in poorer condition (Table 2). In females ( $n = 15$ ), the single variable model that best described survivorship featured ectoparasite load (Table 1). This model also had a low AIC value, was significant ( $\chi^2 = 8.73$ ,  $df = 1$ ,  $P = 0.003$ ) and had a good fit (Pearson  $\chi^2 = 9.0$ ,  $df = 13$ ,  $P = 0.77$ ) with no evidence for overdispersion. Females with no ectoparasites had a significantly greater probability of survival than females with ectoparasites (Table 2). The only ectoparasites present on Saddlebacks from Breaksea Island were feather mites attached to barbules on the inner surface of the primary feathers. There was no significant difference in ectoparasite presence/absence between males and females ( $\chi^2 = 0.24$ ,  $P = 0.62$ ). The only other significant single variable models that were  $\leq 4$  AIC units from the

**Table 1.** Generalized linear models examining survivorship of translocated saddlebacks. The best models are in bold type; additional variables were non-significant in other models with low AIC scores and significant *P* values.

Model	$\chi^2$	<i>P</i>	–Log likelihood	AIC
<b>Male</b>				
MLH	1.15	0.28	6.36	14.72
Ectoparasites	0.40	0.53	6.73	15.46
Tarsus length	0.20	0.66	6.83	15.66
Wing length	2.57	0.11	5.64	13.28
Bill length	0.60	0.44	6.63	15.26
Bill depth	1.30	0.25	6.28	14.56
Bill width	0.07	0.79	6.90	15.80
Bill volume	0.19	0.66	6.84	15.68
Body mass	3.18	0.07	5.34	12.68
<b>Body condition</b>	<b>4.64</b>	<b>0.03</b>	<b>4.61</b>	<b>11.22</b>
<b>Female</b>				
MLH	0.02	0.90	10.09	22.18
<b>Ectoparasites</b>	<b>8.73</b>	<b>0.003</b>	<b>5.73</b>	<b>13.46</b>
Tarsus length	4.60	0.03	7.80	17.60
Wing length	4.19	0.04	7.47	16.94
Bill length	3.26	0.07	8.46	18.92
Bill depth	0.10	0.75	10.05	22.10
Bill width	7.02	0.008	6.59	15.18
Bill volume	4.97	0.03	7.61	17.22
Body mass	1.38	0.24	9.40	20.80
Body condition	0.39	0.53	9.90	21.80
Bill width and wing length	6.52	0.04	6.30	16.60
Bill width and bill volume	7.12	0.03	6.54	17.08

best model were for females, and included bill width, wing length and bill volume (Table 1). We could not combine any of these other variables in models with ectoparasite load because all birds with no ectoparasites survived, which produced a perfect fit in the data and prevented model convergence. Furthermore, bill width, wing length and bill volume variables were non-significant when combined in models together ( $P > 0.13$ ). For both males and females, MLH was not associated with either survival (Table 1) or presence or absence of ectoparasites (males:  $\chi^2 = 0.02$ ,  $P = 0.90$ ; females:  $\chi^2 = 0.22$ ,  $P = 0.64$ ).

## DISCUSSION

Post-release mortality for Erin Island Saddlebacks was 58%, a proportion that is higher than that observed for Saddlebacks released on Ulva Island (7/30 or 23%; S. Oppel and B. Beavan unpubl. data). The Ulva Island translocation used birds sourced from Big Island, which is a small island (23 ha) with mist-nets located next to the banding station (< 10 m). Mortality may have been higher for the Erin Island translocation because many birds were captured away from the hut and consequently were held longer. Erin Island post-release mortality

**Table 2.** Mean and standard deviation (continuous variables) or proportion (categorical variables) of survivors and non-survivors for each parameter.

	Males		Females	
	Survived ( <i>n</i> = 5)	Died ( <i>n</i> = 5)	Survived ( <i>n</i> = 9)	Died ( <i>n</i> = 6)
<b>Continuous variables</b>				
MLH	0.34 (0.16)	0.49 (0.29)	0.45 (0.27)	0.46 (0.17)
Tarsus length (mm)	42.36 (0.31)	42.47 (0.70)	39.74 (0.47)	38.80 (1.12)
Wing length (mm)	99.30 (1.52)	97.10 (2.77)	94.31 (2.48)	91.75 (1.97)
Bill length (mm)	36.44 (1.35)	35.64 (2.14)	35.16 (0.93)	34.18 (1.18)
Bill depth (mm)	7.02 (1.10)	7.58 (0.53)	7.60 (0.38)	7.55 (0.21)
Bill width (mm)	6.00 (0.32)	5.96 (0.19)	6.61 (1.64)	5.62 (0.19)
Bill volume (mm <sup>3</sup> )	515.87 (106.92)	538.19 (68.17)	593.65 (177.69)	483.31 (30.32)
Body mass (g)	83.20 (2.68)	79.00 (4.64)	71.67 (5.27)	68.50 (5.39)
Body condition (g/mm)	1.97 (0.06)	1.86 (0.09)	1.80 (0.14)	1.76 (0.11)
<b>Categorical variables</b>				
<b>Ectoparasites</b>				
Absent	2	3	6	0
Present	3	2	3	6
<b>Time held</b>				
≤ 2 days	3	4	6	4
> 2 days	2	1	3	2
<b>Capture location (<i>n</i> = 46)</b>				
At hut	5	5	9	6
Away from hut	0	8	2	11

occurred immediately following translocation, a result that is consistent with data for other species (Kurzejeski & Root 1988, Wilson *et al.* 1992, Musil *et al.* 1993, but see Armstrong *et al.* 1999).

Beyond capture location, survivorship in translocated Saddlebacks appears to be most strongly related to body condition (males) and ectoparasite load (females). It is unclear why males, but not females, in poor condition were more likely to die. Potentially, female Saddlebacks, as with female House Sparrows *Passer domesticus*, tolerate fasting better than males (Buttemer 1992), a possible adaptation to fluctuations in body mass during parental care duties such as egg-laying and incubation.

The presence of ectoparasites on female Saddlebacks, specifically mites, significantly reduced survivorship. Mite load has been linked to reduced fitness in several avian species including Red Crossbills *Loxia curvirostra* in which Scaly leg Mites *Knemidokoptes jamaicensis* decreased survival (Benkman *et al.* 2005). However, the adverse effects of mites may depend on whether the mite species feeds on blood or dermal detritus and oily feather secretions. Blood-sucking (haematophagous) mites may cause adverse effects such as blood loss, tissue damage, and transferral of pathogens, toxins and irritants (Proctor & Owens 2000), whereas mites that do not feed on blood may be more benign (Proctor & Owens 2000, Dowling *et al.* 2001).

Little is known about feather mites in New Zealand and most studies have examined the effects of one species only, the Fowl Mite *Ornithonyssus bursa*. Fowl Mites are haematophagous but studies of North Island Saddlebacks *Philesturnus carunculatus rufusater* show that experimental removal of Fowl Mites and an undescribed species of dermanyssid mite from nestboxes had no effect on chick mass, fledging date or the number of fledglings produced (Stamp *et al.* 2002). It is unclear whether the species of feather mite we observed feeds on blood or detritus and oil secretions because it still requires identification (K. Hale pers. comm.). However, only two species of feather mites have been observed on South Island Saddlebacks, an unidentified *Analges* and an unidentified *Pterodectes* (Bishop & Heath 1998). We probably observed *Pterodectes* because in other birds *Pterodectes* are usually found on the flight feathers whereas *Analges* are usually found on the head and body (R. Cruikshank, Lincoln University, Christchurch, pers. comm.). Neither of these mite species is likely to be haematophagous (Proctor 2003), so the relationship between mite load and female Saddle-

back survivorship is puzzling. Possibly, feather mite load might be correlated to an adverse but unmeasured variable.

Although there is a strong theoretical basis for a relationship between survivorship and morphology or genetic variation, our study provides little evidence that these attributes affect survivorship in translocated Saddlebacks. Wider bills in female Saddlebacks were associated with increased survival and may indicate superior foraging ability (e.g. Forstmeier *et al.* 2001) but this result should be substantiated by future studies with larger sample sizes. Strong relationships between morphology and survivorship are more generally reported in conjunction with environmental change or selection events (e.g. Seeley 1986, Brown & Brown 1998). Because the environment on Erin Island was similar to that on Breaksea Island, most morphologies may have been equally advantageous, resulting in little selection on Erin Island for birds with specific morphological traits.

Genetic variation in Saddlebacks measured as individual multilocus heterozygosity was not associated with survivorship or ectoparasite load. Studies that have linked individual heterozygosity to disease resistance (Paterson *et al.* 1998, Coltman *et al.* 1999, Acevedo-Whitehouse *et al.* 2003, Whiteman *et al.* 2006) typically find weak (although significant) correlations and assume that variation at a few neutral loci is related to genome-wide heterozygosity, a relationship that is unproven and highly contentious theoretically (Coltman & Slate 2003, Balloux *et al.* 2004, DeWoody & DeWoody 2005). Nevertheless, Saddlebacks with greater genetic variation could have had higher survivorship, but we may not have been able to detect this effect if there was a weak relationship between the microsatellite loci we used and fitness or genome-wide variation in the individuals examined.

In summary, capture location was strongly associated with survivorship for both sexes; minimizing the distance between mist-nets and the banding station should improve survivorship of translocated Saddlebacks. In addition, poor condition and/or ectoparasite load may exacerbate translocation stress although the result was not consistent for both sexes. Morphology and genetic variation did not appear to play an obvious role in survivorship of translocated Saddlebacks. Whether this is true for other species remains to be seen but translocations, which are now used as a standard technique in conservation biology, provide an ideal opportunity to obtain further understanding of how variation in individual traits affects successful establishment of new populations.

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