

Age-specific differences in settlement rates of saddlebacks (*Philesturnus carunculatus*) reintroduced to a fenced mainland sanctuary

Bryce M. Masuda and Ian G. Jamieson*

Department of Zoology, University of Otago, PO Box 56, Dunedin 9054, New Zealand

*Author for correspondence (Email: ian.jamieson@otago.ac.nz)

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Abstract: Mortality and/or dispersal immediately after release can cause translocated populations to fail over both the short and long term, particularly at mainland sanctuaries. However, post-release mortality and dispersal can be limited by releasing individuals with an increased probability of survival and site attachment. We monitored a South Island saddleback (tieke; *Philesturnus carunculatus carunculatus*) population, translocated to a mainland sanctuary, for one year after release to understand the combined influence of post-release mortality and dispersal on initial establishment. We related settlement propensity to three individual characteristics (sex, age class, and previous pairing history) that are known to play a role in the success of reintroductions of other species. Observations of 38 individually marked birds within the sanctuary declined sharply immediately after release, similar to a pattern of post-release mortality observed after a saddleback translocation onto an offshore island. Thereafter, observations declined more gradually until after the start of the first breeding season (5 months after release), likely due to dispersal out of the sanctuary. By the middle of the first breeding season, significantly more subadults than adults survived and remained at the release site, which we attribute to differences in territorial status prior to translocation. Although only 18% of the released birds survived and settled inside the sanctuary at one year after release, our results suggest that, for saddlebacks, releasing a greater proportion of subadults than adults could have a positive effect on reintroduction outcomes at mainland sites where dispersal is of concern.

Keywords: dispersal; establishment; New Zealand; post-release survival; translocation

Introduction

Animal reintroductions are considered to be successful when a self-sustaining population establishes (Griffith et al. 1989) and persists (Seddon 1999) at the release site. The success or failure of a reintroduction is influenced by factors that can affect either short-term population dynamics immediately after release (e.g. number of founders, composition of founder group, translocation methods) or long-term population dynamics (e.g. habitat quality, competitors, predators, pathogens at release site) (Armstrong et al. 1999). By understanding processes that affect founding populations immediately after release, conservation managers may be able to understand why translocations succeed or fail over both the short and long term (Griffith et al. 1989).

Immediately after release, translocated individuals often suffer from high mortality due to stress (Letty et al. 2003; Calenge et al. 2005), injury (Slough 1989) or inexperience (Armstrong et al. 1999). Similarly, high rates of dispersal away from the release site are also commonly observed immediately after release, particularly in bird reintroductions (Musil et al. 1993; Clarke & Schedvin 1997; Tweed et al. 2003). Post-release dispersal can be especially detrimental in mainland reintroductions where released individuals are dependent on release-site-specific habitat quality or active management (e.g. supplementary feeding (Castro et al. 2003) or predator control (Moorhouse et al. 2003)). Therefore, both mortality and dispersal are potential causes of reintroduction failures.

In New Zealand, North Island (N.I.) (*Philesturnus carunculatus rufusater*) and South Island (S.I.) saddlebacks (*P.c. carunculatus*) are two of the avian species most commonly translocated to predator-free offshore islands, due to their extreme vulnerability to introduced mammalian predators

such as ship rats (*Rattus rattus*) (Lovegrove 1996a; Hooson & Jamieson 2003). A number of saddleback reintroductions have been studied to determine what characteristics affect successful establishment on offshore islands. For example, younger individuals were more likely to survive translocations than older individuals (Rasch & McClelland 1993; Pierre 1999), but there was no difference in post-release survival between sexes (Brunton 2000) or between individuals released with familiar and unfamiliar conspecifics (Armstrong & Craig 1995). Furthermore, mortality was typically highest immediately after release (Taylor & Jamieson 2007a), while dispersal was assumed to be negligible in offshore island releases because saddlebacks are poor flyers, with flight distances limited to about 250 m over open water (Newman 1980).

In contrast to the more than 30 translocations of N.I. and S.I. saddlebacks to offshore islands (Lovegrove 1996b; Hooson & Jamieson 2003), there have been only three saddleback translocations to mainland sanctuaries, all of which were in the North Island. No studies have been conducted to determine the role of specific characteristics on mortality and dispersal of saddlebacks released at mainland sanctuaries. The number of mainland sanctuaries established in New Zealand has increased in recent years due to advances in techniques for controlling introduced predators and a growing interest in community-led initiatives (Saunders & Norton 2001; McQueen 2004; Burns et al. 2012). As a result, there will be a greater need to understand factors affecting successful translocations to mainland sanctuaries where dispersal is likely to be an issue.

To understand which factors affect the initial establishment of saddlebacks at a mainland sanctuary, we intensively monitored the first reintroduction of S.I. saddlebacks to a mainland sanctuary (Orokonui Ecosanctuary) for one year after

release. We assessed the combined influence of mortality and dispersal on initial establishment and hypothesised that the short-term survival rate of a mainland release would be lower compared with offshore island releases, due to the added risk of dispersal from the release site. We also related settlement propensity to three factors: sex, age class, and pairing history. These characteristics appear to have played a significant role in the establishment of other species translocated to sites where dispersal is an issue (Carrie et al. 1996; Tweed et al. 2003; Maran et al. 2009).

Methods

Thirty-eight S.I. saddlebacks were translocated to Orokonui Ecosanctuary (Dunedin, New Zealand) from Ulva Island (Stewart Island) between 16 and 18 April 2009 (for specific details, see Masuda et al. (2010)). The release group was composed of 18 females and 20 males, 20 of which were adults and 18 subadults (fledglings and yearlings) and 11 were previously paired and 27 previously unpaired birds. Prior to release, we determined the sex of the saddlebacks from morphological measurements (Taylor & Jamieson 2007b) and their age by plumage characteristics; S.I. saddlebacks can be divided into three age-classes on the basis of delayed maturation of plumage (fledglings and yearlings vs adults) and differential growth of the fleshy wattles (fledglings vs yearlings and adults) (Higgins et al. 2006). All saddlebacks released at Orokonui Ecosanctuary were colour banded for individual identification. The source population on Ulva Island had also been colour banded and intensively monitored so that pairing status could be determined prior to capture for translocation (Masuda 2010).

Orokonui Ecosanctuary (307 ha) is a community-based mainland sanctuary enclosed by a predator-resistant fence (www.oroikonui.org.nz). Following the initial eradication of introduced predators in 2008, continuous predator-monitoring regimes have allowed for a reintroduction programme to be initiated as part of the ecosystem restoration process (Allen 2010). The habitat at Orokonui Ecosanctuary is mostly regenerating native kānuka (*Kunzea ericoides*) forest, which is suitable breeding habitat for saddlebacks (Masuda 2010). Also suitable are the native forest and mixed shrub communities that surround Orokonui Ecosanctuary and are within flying distance for saddlebacks.

Post-release survey

Although attaching radio transmitters to the birds would have enabled higher detection rates for the first 6–8 weeks after release (limit of battery-life of transmitters), there was also the possibility that transmitters could influence the behaviour of released birds (e.g. Richardson 2009). We therefore based our study on intensive surveying within the fenced reserve to determine the proportion of birds that settled inside the sanctuary. Monitoring of the released saddlebacks was initiated on 18 April 2009, 2 days after the initial release of 33 birds (five additional birds were released over the next two days).

Two types of survey were conducted along tracks spaced c. 200 m apart. Initially, during the first 50 days after release, walk-through surveys were conducted during which all saddlebacks seen or heard were identified by their unique colour-band combinations. Each walk-through survey across the entire sanctuary took c. 4 days. From 50 days after release, playback surveys were conducted, as playbacks were thought

to repel translocated N.I. saddlebacks immediately after release at 'Zealandia: The Karori Sanctuary Experience' (hereafter Karori Sanctuary), a mainland ecosanctuary on the North Island (R. Empson, Karori Sanctuary, pers. comm.). Playback surveys involved playing pre-recorded saddleback calls every 200 m from an MP3 player with portable speaker, but were otherwise identical to walk-through surveys. Pre-recorded male rhythmical songs (MRS) were played for 30 s, followed by a 5-min listening period, then an additional 30-s playback again followed by a 5-min listening period, similar to N.I. kōkako (*Callaeas cinerea wilsoni*; Callaeidae) surveys (Flux & Innes 2001). Familiar MRS elicits the strongest response from saddlebacks (Parker et al. 2010) and therefore all pre-recorded MRS used during the playback surveys were obtained from the source population on Ulva Island. Familiar MRS appeared to elicit a similar response from all birds, regardless of sex, age class, or pairing history, during both the capture for translocation on Ulva Island and the post-release surveys at Orokonui Ecosanctuary (BMM, pers. obs.).

Each playback survey was completed in c. 7 days. A total of six walk-through surveys were conducted between 18 April and 10 June 2009, and four playback surveys were conducted between 11 June and 27 October 2009, after the start of the breeding season. Both walk-through and playback surveys were only conducted during favourable weather conditions (wind less than force 5 on the Beaufort scale and no heavy rainfall). There were no new sightings of previously unobserved saddlebacks during the breeding season (13 September to 30 April) and therefore the post-release surveys likely resulted in complete detection of all saddlebacks living inside the sanctuary. Post-release monitoring was conducted only inside Orokonui Ecosanctuary, because we were specifically interested in settlement within the sanctuary.

Data analysis

Survival estimations and assumptions

Resighting data collected during the post-release surveys at Orokonui Ecosanctuary were used to estimate apparent post-release survival and resighting probabilities (Lebreton et al. 1992). Because the population was open to emigration and the fate of the birds that left the study site was unknown, apparent survival (Φ) was defined as the probability of a saddleback remaining within Orokonui Ecosanctuary and surviving between consecutive surveys (Williams et al. 2002). Resighting probability (p) was defined as the probability of a live saddleback being observed during a sampling occasion. Maximum likelihood estimates of apparent survival and recapture probability were based on the Cormack–Jolly–Seber (CJS) model for open populations (Lebreton et al. 1992). The CJS model assumes that marked animals in the population have the same probabilities (1) of being resighted and (2) of survival, and (3) that marks are neither lost nor missed and are recorded correctly, (4) that all sample periods are instantaneous, (5) that any emigration from the sample area is permanent, and (6) that the fate of each animal with respect to capture and survival probability is independent of the fate of any other animal (Williams et al. 2002).

CJS open-population models to estimate apparent survival and resighting probabilities were applied in the program MARK (White & Burnham 1999), which was accessed through the R (R Development Core Team 2010) package RMark (Laake & Rexstad 2009).

Survival model and analysis

An information theoretic approach based on Akaike's Information Criterion (AIC) was used for model selection (Burnham & Anderson 1998). Modelling was initiated by testing the recapture history of each individual for goodness-of-fit with RELEASE Tests 2 and 3 as a stand-alone test in program MARK. Test 2 and Test 3 test for independence and lack of heterogeneity, respectively, and thus non-significant results from these tests suggest the data are a good fit to the global CJS model (Burnham et al. 1987; Lebreton et al. 1992).

The goodness-of-fit of the global model was also evaluated by using a parametric bootstrap routine (Burnham et al. 1987; Lebreton et al. 1992; Burnham & Anderson 2002). The observed deviance of the global model was divided by the expected deviance generated with 100 simulations using the bootstrap goodness-of-fit test, to calculate a variance inflation factor (\hat{c}). A \hat{c} value of 1 indicates the model fit the data perfectly, and \hat{c} values of < 2 suggest the most highly parameterised model (which included interactions between all factors) was an acceptable fit to the data (Lebreton et al. 1992). Overdispersion was corrected by using \hat{c} to adjust model selection and parameter estimates.

The best approximating candidate model was selected by determining the minimum quasi-likelihood AIC (QAIC), after incorporating \hat{c} to allow for minor overdispersion in the data. Candidate models were selected by assessing the difference between QAIC values ($\Delta QAICc$) and ranked based on the lowest QAICc (Burnham & Anderson 1998). Models with a $\Delta QAICc \leq 2$ were considered to have an equal likelihood of correctly describing the data (Burnham & Anderson 2002). Model averaging (Johnson & Omland 2004) of the top model-set was used to estimate apparent survival rates for different age-classes over the survey period.

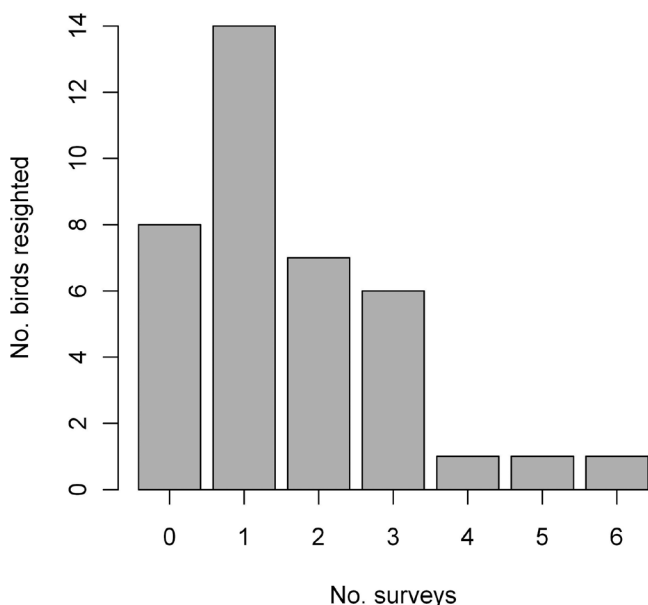


Figure 1. Number of post-release surveys conducted at Orokonui Ecosanctuary from 18 April to 27 October 2009, during which 38 released saddlebacks (*Philesturnus c. carunculatus*) were resighted.

Results

Resighting occasions

Most of the release group (79%; 30 of 38 individuals) were resighted during the post-release surveys. All birds that were resighted survived the first 48 hours after release, which can be a period of high mortality for translocated saddlebacks (Taylor & Jamieson 2007a). Although the majority of released individuals were resighted, the frequency of resighting per individual was low; 90% (27 of 30) of resighted individuals were observed in fewer than 4 of the 10 surveys conducted (Fig. 1). Four adult saddlebacks were opportunistically observed outside the predator-resistant fence by members of the public: two were seen 56 days post-release (2.1 km from the release site), one 61 days post-release (1.7 km), and one 154 days post-release (2.4 km). Only one of the four birds (seen 61 days post-release) was previously observed in the sanctuary (37 days post-release). All four birds were not observed again after being seen outside the fence.

Observed post-release survival

The majority of the released individuals (63%, 24 of 38) disappeared during the first 70 days after release (Fig. 2). Survival remained constant between 70 and 140 days after release (14 birds alive), then decreased again between 140 and 195 days after release (14 to 9 birds alive; Fig. 2). Assuming at least some of the decline in survival was due to dispersal outside the survey area, there appear to be two post-release mortality and dispersal stages: (1) after the release (1–70 days post-release) and (2) after the start of the breeding season (140–195 days post-release). Therefore, we initially examined the survival of saddlebacks until both the start and middle of the breeding season.

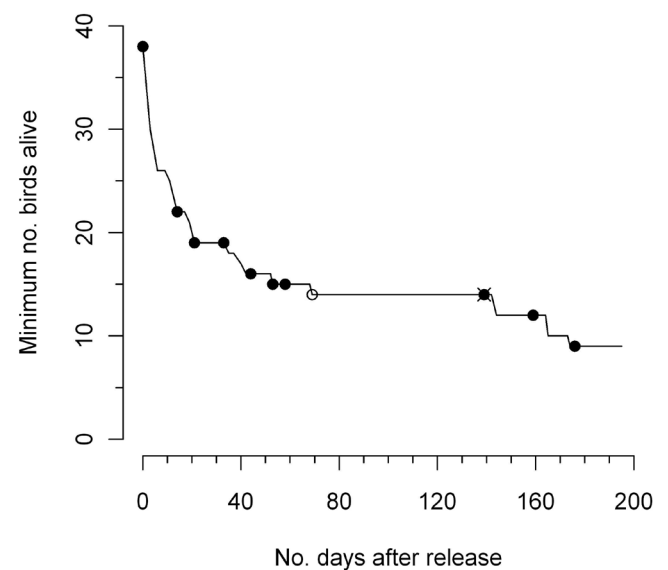


Figure 2. Minimum number of released saddlebacks (*Philesturnus c. carunculatus*) alive within Orokonui Ecosanctuary, on the basis of post-release surveys. Closed circles indicate the start of each survey and the single open circle indicates the end of the survey period before the onset of winter, during which no surveys were conducted. × indicates the start of the breeding season.

The 14 individuals that survived until the start of the breeding season (140 days post-release; Fig. 2) consisted of 4 of 20 (20%) released adults, compared with 10 of 18 (56%) released subadults ($\chi^2 = 5.15, P = 0.02$) of a nearly equal sex ratio (8 males and 6 females; $\chi^2 = 0.18, P = 0.67$). There was no significant difference in survival rates between previously paired (36%, 4 of 11) and unpaired individuals (37%, 10 of 27) ($\chi^2 = 0.002, P = 0.96$).

After the start of the breeding period, a further 5 individuals disappeared (Fig. 2), leaving 9 birds settled inside the sanctuary. The 9 individuals were composed of 2 of the 4 (50%) remaining adults and 7 of the 10 (70%) remaining subadults. Combining both periods (i.e. before and immediately after the start of the breeding season), the percentage of subadults that survived until the middle of the breeding season (7 of 18, 39%) was significantly greater than that of surviving adults (2 of 20, 10%) ($\chi^2 = 4.37, P = 0.04$). There was no significant difference in survival between sexes (5 males and 4 females; $\chi^2 = 0.04, P = 0.84$), nor between previously paired (2 of 11, 18%) and unpaired individuals (7 of 27, 24%) ($\chi^2 = 0.26, P = 0.61$).

Two additional saddlebacks disappeared at the end of the breeding season, 1 year after the release. As a result, the one-year survival rate was 0.18 (7 of 38 released individuals).

Apparent post-release survival rates using MARK

We re-examined the previously described differences in observed survival between adults and subadults with Program MARK to provide a more robust estimate of survival and resighting probabilities inside the sanctuary. After grouping the observations by survey, Test 2 ($p = 0.98$) and Test 3 ($p = 0.86$) in the program RELEASE indicated the global model (d.f. = 16) was a good fit to the global CJS model. The deviance of the global model (81.5) was divided by the mean bootstrap deviance (54.5) to obtain an estimated \hat{c} value of 1.5. The \hat{c} value was less than two, indicating that the global model was a good fit to the data.

Models 1–3 all had a similar likelihood and QAICc weighting ($\Delta QAICc < 2$; Table 1) and were therefore all plausible models. Two of these top three models suggested that survival varied by age class (Models 2 & 3; Table 1), while

time since release also appeared to play a role in the post-release survival rate (Model 2; Table 1). However, variation in resighting rate contributed uncertainty to survival estimates (Model 1 & 3; Table 1). Model averaging indicated that the lowest survival rates occurred within the first two months after release and estimated a lower survival rate for adults than subadults (Fig. 3). Overall, these results are consistent with our previous analysis based on observed survival rates, and indicate that both age class and time contributed to the variation in post-release survival of saddlebacks inside the sanctuary.

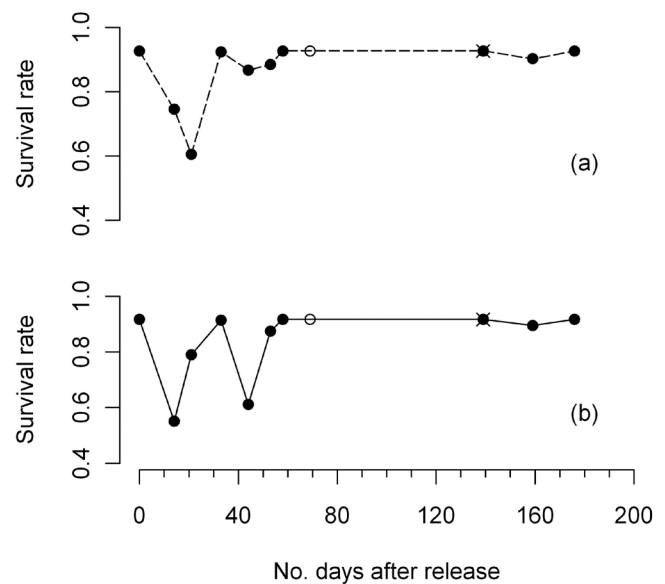


Figure 3. Post-release survival estimates based on model averaging for (a) subadult and (b) adult saddlebacks (*Philesturnus c. carunculatus*) translocated to Orokonui Ecosanctuary. Closed circles indicate the start of each survey period and the single open circle indicates the end of the survey period before the onset of winter. × indicates the start of the breeding season. Ten surveys were conducted within the first six months after release.

Table 1. Model selection for survival (Φ) and recapture (p) probabilities of translocated saddlebacks (*Philesturnus c. carunculatus*) at Orokonui Ecosanctuary from 18 April to 27 October 2009. Ten of 49 models, with $\Delta QAICc \leq 6$, are listed, ranked by ascending $\Delta QAICc$. The variance inflation factor is 1.50.

| Rank | Model description ¹ | QAICc ² | $\Delta QAICc$ | QAIC weight | K ³ | QDeviance |
|------|-----------------------------------|--------------------|----------------|-------------|----------------|-----------|
| 1 | $\Phi_c P_{time}$ | 214.17 | 0.00 | 0.33 | 11 | 91.75 |
| 2 | $\Phi_{age * time} P_c$ | 215.77 | 1.61 | 0.15 | 5 | 108.03 |
| 3 | $\Phi_{age} P_{time}$ | 216.16 | 1.99 | 0.12 | 12 | 91.08 |
| 4 | $\Phi_{time} P_c$ | 216.76 | 2.60 | 0.09 | 4 | 111.26 |
| 5 | $\Phi_{age * time} P_{age}$ | 217.58 | 3.41 | 0.06 | 6 | 107.54 |
| 6 | $\Phi_{time} P_{age}$ | 217.90 | 3.73 | 0.05 | 5 | 110.16 |
| 7 | $\Phi_{age * time} P_{sex * age}$ | 218.18 | 4.01 | 0.04 | 8 | 103.37 |
| 8 | $\Phi_{time} P_{sex * age}$ | 218.40 | 4.24 | 0.04 | 7 | 106.01 |
| 9 | $\Phi_{time} P_{time}$ | 218.72 | 4.55 | 0.03 | 14 | 88.09 |
| 10 | $\Phi_{sex * age * time} P_c$ | 219.25 | 5.08 | 0.03 | 8 | 104.44 |

¹ Model factors included c = constant survival and resighting, age = age class (subadult or adult) at release, time = days after release, and sex = male or female.

² Quasi-likelihood Akaike's Information Criterion with small sample correction.

³ Number of parameters.

Discussion

Was the decline in the minimum number alive due to mortality or dispersal?

We found that the majority of saddlebacks released at Orokonui Ecosanctuary disappeared within 70 days after release. Although some losses could have been dispersal related, we speculate that mortality immediately after release could also be significant. High mortality has been observed in a number of reintroduced species and is often linked to translocation-induced stress and unfamiliarity with the release site (Letty et al. 2003; Calenge et al. 2005; Hamilton et al. 2010). In saddlebacks, translocation-induced stress was thought to be responsible for post-release mortality during the first two weeks, and primarily within the first 24 hours, of an island reintroduction (Taylor & Jamieson 2007a). Therefore, the initial steep decline in the minimum number alive observed during the first two to three weeks after release at Orokonui Ecosanctuary (Fig. 2) may have been due partly to stress-related mortality.

On the other hand, the more gradual decline in the minimum number alive observed after the first three weeks may have been associated with dispersal from the sanctuary. Dispersal out of Orokonui Ecosanctuary was indeed confirmed by opportunistic observations of four individual saddlebacks outside the sanctuary after the first three weeks post-release. Given that systematic surveys were not conducted outside the sanctuary and there was large area in which saddlebacks could disperse, it is likely that more than four individuals dispersed outside the sanctuary. Translocated saddlebacks are known to range widely after release (Armstrong & Craig 1995), and N.I. saddlebacks fitted with transmitters and released at Boundary Stream Mainland Island dispersed up to 1952 m from the release site (Sullivan 2006). Post-release dispersal in other reintroduced bird species has been associated with homing behaviour of adults back to their original territories (Oppel & Beaven 2002; Parker et al. 2004).

Our results also indicated that five single birds, which settled in the sanctuary and survived over winter, were not resighted soon after the start of the breeding season. Their relatively sudden disappearance could be due to individuals searching for mating partners outside the fenced area, even though the five individuals that disappeared were of a nearly even sex ratio (three males and two females). Since the peak in saddleback mortality typically occurs over the winter (Davidson & Armstrong 2002), it is possible in this case that their disappearance was again dispersal related. If so, then it further emphasises that 'leakage' outside the fenced area will limit or slow the establishment of saddleback populations in mainland reserves such as Orokonui.

Which factors contributed to variation in post-release settlement patterns?

We determined that the initial settlement of saddlebacks released at Orokonui Ecosanctuary was age-specific, with subadults (fledglings and yearlings) more likely to survive and settle within the sanctuary than adults. Age-related post-release dispersal by saddlebacks was observed at Boundary Stream Mainland Island where adults dispersed farther than subadults immediately after release (Sullivan 2006). Therefore, adults appear to exhibit a greater tendency to disperse during translocations, part of which may be associated with homing behaviour (see above).

These potential differences in post-release dispersal rates

between subadults and adults at Orokonui Ecosanctuary may be related to age differences in natal dispersal and corresponding territoriality status in the source population at the time of capture. Natal dispersal is a three-step process involving: (1) natal site departure, (2) transient phase, and (3) territory settlement (Clobert et al. 2001). Subadult saddlebacks were likely in the natal dispersal or transient phase at the time of capture (early autumn) on Ulva Island and were all unpaired. In contrast, adults were both paired and unpaired but all were territorial on Ulva Island at the time of capture. Therefore, the association between age and territorial status (but not pairing history) and dispersal is possibly due to subadults searching for a territorial site to settle on after release at Orokonui Ecosanctuary, while adults may have been less likely to settle after release because of their previous territorial status on Ulva Island. In the case of saddlebacks, territorial adults typically live on the same territory year-round for their entire lives and therefore may be particularly prone to disturbance, leading to post-release dispersal and homing behaviour after translocation.

How does the Orokonui release compare with other saddleback releases?

The observed survival rate 12 months after release for founding saddlebacks from a number of offshore island reintroductions ranged from 0.25 to 0.84 (Table 2). This broad range is partly due to variation in post-release monitoring efforts, among other factors. For example, the relatively low survival rates observed on Breaksea (Rasch & McClelland 1993), Motuhora (Brunton 2000) and Little Barrier islands (Parker & Laurence 2008) are likely the result of conducting a limited, one-off survey. The large distance between the source and release sites (>1000 km) and resulting extended time in captivity may have played a role in the relatively low survival rate of saddlebacks translocated to Motuara Island in the Marlborough Sounds (Pierre 2000). Variable survival rates may also be associated with the season of release (Long Island; Hale 2008) and possible predation (Erin Island; Taylor & Jamieson 2007a). On the other hand, a relatively high survival rate one year after release was observed on Ulva, Tiritiri Matangi, Mokoia and Motuihe islands (0.70–0.84), where saddlebacks were intensively monitored.

The survival rate one year after release at Orokonui Ecosanctuary (0.18) was lower than for all other offshore island populations, as well as for two other fenced mainland reserves, Bushy Park Reserve (0.50) and Karori Sanctuary (0.49) (Table 2). Bushy Park Reserve is nearly completely surrounded by pasture, and saddlebacks typically do not fly across open areas (Newman 1980). As a result, Bushy Park Reserve is a virtual island for saddlebacks, with dispersal outside the predator-resistant fence unlikely. Karori Sanctuary, on the other hand, is surrounded by patches of forest and therefore is more similar to Orokonui Ecosanctuary in terms of potential dispersal outside of the predator-resistant fence. Assuming subadults are more likely to settle inside sanctuaries, the difference in survival rates may have been due to the different age-class compositions of the release groups. However, because N.I. saddlebacks do not have delayed plumage maturation like their S.I. counterpart, this hypothesis remains untested.

Implications for reintroductions of other species

Relatively few studies have examined age as a factor influencing reintroduction success (but see Sarrazin & Legendre 2000; Robert et al. 2004). Our study suggests younger individuals

Table 2. Survival rates of translocated North Island (N.I.) (*Philesturnus carunculatus rufusater*) and South Island (S.I.) saddlebacks (*Philesturnus c. carunculatus*) monitored after release.

| Release location | Release site (ha) | Date of release | Date of survey | No. survey months | No. released | Minimum no. survived | Survival over 12 months ¹ | References |
|---------------------|---|-----------------|----------------|-------------------|-----------------|----------------------|--------------------------------------|-----------------------------|
| S.I. Mainland | Orokonui Ecosanctuary (307 ha) | April 2009 | April 2010 | 12 | 38 | 7 | 0.18 | This study |
| N.I. Mainland | Karori Sanctuary ² (225 ha) | June 2002 | June 2003 | 12 | 39 | 19 | 0.49 | (Armstrong 2011) |
| | BSMI ³ (800 ha) | Sept. 2004 | Dec. 2004 | 3 | 37 | 0 | 0 | (Armstrong 2011) |
| | Bushy Park Reserve ² (98 ha) | June 2006 | June 2007 | 12 | 34 ⁴ | 17 | 0.50 | (Thorne 2007) |
| S.I. Island | Breaksea I. (170 ha) | March 1992 | March 1993 | 12 | 59 | 30 | 0.51 | (Rasch & McClelland 1993) |
| | Motuara I. (59 ha) | March 1994 | January 1995 | 10 | 26 | 13 | 0.44 | (Pierre 1999) |
| | Ulva I. (267 ha) | April 2000 | April 2001 | 12 | 30 | 23 | 0.77 | (Taylor 2006) |
| | Erin I. (67 ha) | April 2004 | February 2005 | 10 | 20 | 7 | 0.28 | (I. Jamieson, unpubl. data) |
| N.I. Island | Long I. (142 ha) | August 2005 | May 2006 | 9 | 45 | 26 | 0.48 | (Hale 2008) |
| | Cuvier I. (170 ha) | January 1968 | January 1969 | 12 | 29 | 12 | 0.41 | (Parker & Laurence 2008) |
| | Stanley I. (100 ha) | January 1977 | January 1978 | 12 | 24 | 11 | 0.46 | (Parker & Laurence 2008) |
| | Tiritiri Matangi I. (197 ha) | February 1984 | February 1985 | 12 | 24 | 19 | 0.79 | (Parker & Laurence 2008) |
| | Little Barrier I. (3083 ha) | February 1984 | February 1985 | 12 | 50 | 22 | 0.44 | (Parker & Laurence 2008) |
| | Mokoia I. (135 ha) | April 1992 | October 1992 | 6 | 36 | 33 | 0.84 | (Armstrong & Craig 1995) |
| | Motuhora I. (143 ha) | March 1999 | Nov. 1999 | 8 | 40 | 16 | 0.25 | (Brunton 2000) |
| Motuihe I. (179 ha) | August 2005 | August 2006 | 12 | 20 | 14 | 0.70 | (Parker & Laurence 2008) | |

¹In cases where post-release surveys were conducted over <12 months, the proportion survived was converted to monthly survival rate and then multiplied by itself 12 times.

²Enclosed by a predator-resistant fence.

³Boundary Stream Mainland Island; unfenced, intensively managed mainland reserve.

⁴Excluding four birds released in December 2006.

are more likely than older individuals to settle near the release site, possibly due to differences in territorial status prior to translocation. Therefore, preferentially selecting and releasing non-territorial subadults over territorial adults could increase settlement rates in mainland sanctuaries where dispersal is an issue. Dispersal remains a significant issue in animal reintroductions (Griffith et al. 1989; Hardman & Moro 2006) and factors that could mediate its consequences deserve further study. Nevertheless, the factors affecting post-release establishment are often species-specific and therefore conservation managers may need to examine the role of age in post-release establishment on a case-by-case basis.

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Editorial Board member: Hannah Buckley

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