Translocation of hihi *Notiomystis cincta* to Maungatautari, a mainland reserve protected by a predator-exclusion fence, Waikato, New Zealand

John G. Ewen[1*], Kevin A. Parker[2], Kate Richardson[3,1], Doug Armstrong[3] & Chris Smuts-Kennedy[4]

[1*]*Institute of Zoology, Zoological Society of London, Regents Park, NW1 4RY, London, UK*

[2]*Institute of Natural Sciences, Massey University, Private Bag 102904, North Shore Mail Centre, Auckland, New Zealand*

[3]*Ecology Group, Institute of Natural Resources, Massey University, Palmerston North, New Zealand*

[4]*Maungatautari Ecological Island Trust, 64 Alpha Street, Cambridge, New Zealand*

*Corresponding author e-mail: John.Ewen@ioz.ac.uk

SUMMARY

In March 2009, 79 hihi (stitchbird) *Notiomystis cincta* were translocated from Tiritiri Matangi and Little Barrier (Hauturu) Islands to Maungatautari, a 3,255 ha New Zealand mainland reserve with a predator (exotic mammals) exclusion fence. Genetic management, by mixing founders from both a reintroduced and highly productive site (Tiritiri Matangi) and the only naturally occurring extant population (Little Barrier), appears successful with at least one mixed pairing producing fledglings in the first breeding season after release. Monitoring this population is challenging due to the large area and rugged terrain of the reserve. However, closed mark-recapture analysis based on a 15-day survey about 1 year after release indicated that between 15 and 41 (19 - 52%) of the translocated hihi had survived. Unringed hihi were also observed during this survey (25 observations but it is unknown how many of these were the same individuals), indicating successful breeding in the first year. If they persist and thrive in the longer term, this translocation will provide an important hihi population at a large mainland site and will contribute to the ongoing ecological restoration of Maungatautari.

BACKGROUND

Hihi (or stitchbird) *Notiomystis cincta* are small, sexually dimorphic forest-dwelling passerines. They are sole representatives of an endemic bird family of New Zealand (Notiomystidae; Ewen *et al*. 2006, Driskell *et al*. 2007). Although once widespread throughout North Island, they declined following European colonisation and became restricted to a single offshore population on 3,083 ha Little Barrier Island (Hauturu). The current population size on Little Barrier is unknown but there are estimates of between 600 to 6,000 birds (Taylor *et al*. 2005). Methods are currently being trialled to more accurately estimate the hihi population size on Little Barrier. Hihi have a generalist diet that consists of insects, nectar and fruit, making them a potentially important pollinator and seed disperser of native plants.

Conservation management of the Little Barrier population has included eradication of two

introduced mammalian predators (feral cat *Felis catus* by 1980, and kiore or Polynesian rat *Rattus exulans* in 2004). At the same time there has been a focus on establishing additional populations at other sites through reintroduction. Prior to the translocation described here, there had been 17 reintroductions to seven sites. These reintroductions have met with mixed success. Populations on Hen (Taranga) (founded in 1980 and 1981) and Cuvier (Repanga) (founded 1982 and 1985) Islands failed to persist. The population on Mokoia Island (founded 1994) was moved due to persistent low adult survival and predicted low population viability despite intensive management, with the remaining birds translocated to Kapiti Island in 2002. Early reintroduction attempts to Kapiti did not succeed (1983, 1985 and 1990) but a small population persisted in low numbers following further reintroductions in 1991 and 1992 until a change in management (introduction of supplementary feeding) resulted in substantial population growth from about the year 2000 onwards (Chauvenet *et al*., unpublished).

In 1995 and 1996 a hihi population was established on Tiritiri Matangi and this population responded well to management, with high productivity and adult survival and hence little risk of extinction in the short term (Ewen & Armstrong 2007). Since 2005, reintroduction attempts have focused on translocating juvenile and adult hihi from Tiritiri Matangi to North Island 'mainland island' sites where non-native mammals have been eradicated or controlled, including to the predator-proof fenced Karori Wildlife Sanctuary (Wellington) in 2005 and the 'Ark in the Park' project within the Waitakere Ranges (Auckland) in 2007 and 2008. The fate of these populations is currently being monitored.

Hihi productivity on Tiritiri Matangi Island has allowed 'harvesting' (removal) of some juvenile birds for reintroduction purposes without compromise to population viability (Armstrong & Ewen *in press*). The known low risk to population viability on Tiritiri Matangi and the contrasting lack of information about impacts on removing hihi from Little Barrier Island has led to Tiritiri Matangi becoming the favoured source population for translocations. Whilst the demographic impacts on harvesting the Tiritiri Matangi population are fairly well understood the genetic consequences of this strategy are less clear. Certainly the Tiritiri Matangi population was generated through a strong bottleneck (Brekke *et al*. 2011) and there is evidence for inbreeding depression (Brekke *et al*. 2010). Here we describe a new approach for translocating hihi by mixing a large number of juvenile birds from a source population with low demographic risk (i.e. Tiritiri Matangi) and a smaller number of more outbred individuals from the species' sole extant native population on Little Barrier Island. The hope is that sufficient numbers of individuals can be released to enhance establishment success and that enough birds from Little Barrier survive post-release to contribute unrelated individuals with the assumption that this will offset possible inbreeding depression.

ACTION

Maungatautari: Maungatautari Restoration Project encompasses a large (3,255 ha) area of mixed broadleaf/podocarp hill forest on Maungatautari mountain in the Waikato region of New Zealand's North Island (38°02'S, 175°57'E). The forest comprises a diversity of habitats that can be divided into nine vegetation association zones, according to altitude and history (Bruce Clarkson pers. comm.). Some timber extraction occurred on the lower slopes in early European settlement times, but much old-growth forest still remains. The forested mountain (maximum altitude 797 m a.m.s.l.) has been fenced around its base with a 47 km long Xcluder™ fence (installation completed 2006) and most exotic mammalian species have now been eradicated within it. Continuing management is aimed at removing those that remain (European rabbit *Oryctolagus cuniculus*, brown hare *Lepus europaeus* and house mouse *Mus musculus*). There are approximately 260 km of pest monitoring lines (with more than 3,000 tracking tunnels) within the reserve for mammal pest detection purposes. The project aims to permanently eliminate all introduced mammals and to restore to the forest a healthy

diversity of indigenous plants and animals. Hihi are the fourth endemic bird species to be reintroduced into the reserve following releases of North Island brown kiwi *Apteryx australis* (in 2005), takahē *Porphyrio mantelli* (2006) and North Island kaka *Nestor meridionalis* (2007). Also in 2009, whitehead *Mohoua albicilla* and yellow crowned kākāriki *Cyanoramphus auriceps* were released. Successful reintroduction of hihi would complete the establishment of an avian nectivore guild, as the two other extant endemic nectivorous species, tui *Prosthemadera novaeseelandiae* and bellbird/korimako *Anthornis melanura* are present.

Maungatautari is surrounded by pasture land used predominantly for dairy production. As this farmland habitat represents a hostile environment affording little or no suitable habitat, it is hoped that this generates an 'island effect' preventing hihi from dispersing from the protected reserve forest.

Aims and planning: The aim of the translocation was to establish a hihi population in a large forested area with potential to support a large hihi population requiring little direct management (beyond maintaining the site as free of non-native mammal predators). Planning was initiated in early 2004 and involved: i) seeking support from local Iwi (Māori with historical ownership of the area); ii) securing financial support; iii) obtaining approval and permits from the New Zealand Department of Conservation to undertake the translocation; iv) site preparation including provision of supplementary feeding stations; v) preparation of translocation equipment; and vi) identifying available personnel for hihi capture, movement and post-release monitoring.

Supplementary feeding has been shown to improve survival and enhance reproductive output of reintroduced hihi populations (Armstrong *et al*. 2007, Chauvenet *et al*. unpublished) and also aid in post-release monitoring. Six feeding stations providing a sugar water solution were constructed at Maungatautari, and placed within the 63 ha 'southern sub-enclosure' from which all exotic mammals had been removed (including rabbits, hares and house mice). The rationale for placing feeders in this small portion of the reserve was to facilitate viewing of the birds by the public (for conservation advocacy), provide an insurance food supply if natural food was lacking, and assess whether hihi could survive in the rest of the mountain without reliance on supplementary food.

Tiritiri Matangi Island: Tiritiri Matangi (220 ha) lies about 3 km off the Whangaparaoa Peninsula and 25 km north of Auckland city. The island has a long history of human use and habitation by Māori (Kawerau a Maki and Ngati Paoa) and Europeans, and was farmed from the 1890s until 1971. Most of this formerly forested island was grass and bracken *Pteridium exculentum*-covered until 1983, when a revegetation program began (Cashmore 1995). During 1983-1995, the island was replanted with some 280,000 native trees mostly using local seed stock (Mitchell 1985) and kiore were eradicated in 1993. In September 1995, 38 hihi (20 males, 18 females) were translocated to Tiritiri Matangi from Little Barrier Island. The majority disappeared within the first month leaving an initial founder population of 12 males and four females. A further 13 hihi were translocated in August 1996 to bolster numbers. The population has grown with supportive management (supplementary feeding with sugar water and control of *Ornithonyssus bursa* mites on nestlings) to around 150 adult hihi and is currently estimated to remain about this number under current harvesting levels (Armstrong & Ewen *in press*).

Little Barrier Island: 3,083 ha Little Barrier Island (Hauturu) was purchased by the Crown in 1894 and established as New Zealand's first nature reserve. It is one of the most pristine native ecosystems remaining in New Zealand. It lies 80 km north-east of Auckland and provides refuge to many of New Zealand's endangered animals and plants. The island is mountainous (rising to 722 m) and heavily forested. The island has not entirely escaped human modification with centuries of Māori association (inhabited by Tainui and later Ngāti Wai and Ngāti Manuhiri) including the introduction of kiore, and European influence (cattle and sheep grazing, and introduction of

cats in about 1880). Nearly one third of the forest cover was lost (burnt or cut down) prior to crown purchase but natural regeneration to native forest is now well advanced. The sole extant population of hihi have persisted, largely unmanaged, on the island since becoming extirpated in all other areas by about 1883. The fate of hihi is still closely linked to the viability of this one population and it remains the long-term goal of the Hihi Recovery Group to have at least one other hihi population that does not require supportive management (Taylor *et al*. 2005).

Portable aviary design: Five portable aviaries (each 1.2 x 2.4 m x 1.8 m high) were constructed for the translocation. They can be fitted together in groups of two and three which allows for a double-door entry system to be incorporated. They were designed such that they could be dismantled down to flat panels to enable stacking and transport. The five dismantled aviaries form a stack (of about 30 panels) 2.4 m long, 1.8 m wide and about 1.5 m high that can easily be transported on a car trailer. Aviaries are double lined with garden shade cloth as an internal lining to minimise potential impact injuries of birds. Five or six hihi were accommodated in each aviary.

Capture and health screening: On Tiritiri Matangi, juvenile hihi were caught either in mist-nets or in supplementary feeder cage traps by a group of 12 people working in teams over two days (1-2 March 2009). At this time of year independent juvenile birds often congregate in the lower gullies of the island where water is present (either in natural water bodies or managed water baths). In an attempt to minimize relatedness of the cohort of birds to be translocated, we took the juveniles from as many different clutches as possible (whilst acknowledging the high levels of extra-pair paternity in this species). This could be done as all hihi were ringed as nestlings so their clutch origin was known. Decisions based on social relatedness by this method (although somewhat crude) were unavoidable given the time and expense otherwise required for paternity analysis. On Little Barrier Island from 19-22 March 2009, a team of eight people caught hihi of mixed age and sex in mist-nets set predominantly along ridges along the track systems of the south-west corner of the island.

Upon capture individual birds were placed in a cloth bag and transported to the holding aviary for health screening. Permanent aviaries are present at each site and additional smaller portable aviaries were erected on Tiritiri Matangi to hold the high numbers of birds captured. Birds were first subjected to a physical examination (for obvious signs of injury, disease or parasites) and weighed. Individuals in reasonable or good body condition and without obvious injuries or unusual parasite infestations were retained for further screening and quarantine. Health screening entailed taking a small blood sample (via brachial venipuncture) and preparing a thin blood smear, and swabbing the cloaca (see Ewen *et al. in press*). All smears and swabs were sent to a commercial laboratory for analysis (Gribbles Veterinary NZ, Mt. Wellington, New Zealand). Estimated white blood cell (WBC) counts were made from smears, and swabs were cultured for the enteric bacteria *Salmonella* and *Yersinia* (for details of laboratory protocols see Parker *et al*. 2006). Individuals were not translocated if their i) estimated WBC were $\geq$ 20 x 10 g/L, ii) weights were below 28 g for females or 33 g for males, at the end of the holding period. Holding times (5 or 6 days duration) were determined by the laboratory test processing times; this was in fact faster in contrast to previous translocations where holding times ranged from 9-14 days.

Our target was to transfer 60 juvenile hihi with an even sex ratio from Tiritiri Matangi and 20 hihi of mixed age and with a two-thirds male bias from Little Barrier. We also planned to catch slightly higher numbers in each location to buffer against poor health leading to rejecting of some birds from translocation. Once the target number of hihi had been caught for translocation two medication treatments were administered in the birds sugar water. During the first two days they were provided with toltrazuril (Baycox, Coccidiocide for Piglets, Bayer New Zealand) on two consecutive days at a dosage of 0.125 mg/mL sugar water, to control coccidia (intracellular parasites). Starting on the third day and continuing daily until the day prior to

translocation the birds received itraconazole (Sporanox, Jannsen-Cilag) at an estimated dosage of 5 mg/kg per day for the control of aspergillosis (a disease caused by *Aspergillus* fungi). Coccidian infections and aspergillosis were targeted because they are known to cause health problems in hihi (Ewen *et al. in press*). All food (except medicated sugar water) was removed for one hour in the morning to increase the chances that birds would ingest medication supplied at this time, after which this was removed and a full range of fresh food provided (see below).

Husbandry and translocation: Aviaries were 'prepped' prior to birds being caught. Prepping involved removing all loose leaf litter to leave a bare soil floor, and checking for damaged linings to the walls and roof. Fresh leaf litter was spread about 5 - 10 cm thick on the aviary floors and extensive fresh cut vegetation of robust nature (i.e. tree species unlikely to wilt rapidly) was used to fill the aviaries (particularly the ends of each rectangular flight as natural perches and to allow maximal distance from any person servicing the aviary). Birds were maintained with a range of foods, as guided by previous translocations. Two removable food trays were hung in each flight (one each end) and water trays (for drinking and bathing) placed on the aviary floor. Food (provided in small plastic tubs in each tray) included one each of sugar water (half cup raw sugar to 500 mL water), a jam:honey mix (¼ cup berry jam, ¼ cup honey, ½ tablespoon ProNutro cereal and ½ tablespoon bee pollen mixed in hot water until dissolved), Wombaroo™ (½ cup to 500 ml cold water), a fruit:vegetable puree (a blend of ½ carrot, ⅓ apple, ⅓ pear, ¼ orange, ⅓ banana, 10 grapes, 500 g corn kernels, 50 g peas and sugar water as needed to obtain a runny consistency). Sugar water and Wombaroo™ were also provided in hummingbird feeders (Perky Pet Inc.) and wedges of fresh cut fruit (apple, orange, pear and banana) were secured to branches. Food and water was changed twice daily. In addition, fresh cut vegetation with ripe fruit known to be eaten by hihi was added daily and about five wax moth (*Galleria* sp.) larvae per bird were added as insect forage. At all other times contact was avoided with the birds to reduce disturbance/stress.

On the day of translocation, birds were allowed to feed for the first hours of light after which excess vegetation was removed to allow easy capture using hand nets. All individuals were reweighed and placed in small double-ended wooden transfer boxes. Up to five birds were placed together in each end (provided with fruit for the short duration of a few hours for their trip). Birds were flown by helicopter between source and release locations.

Release: On arrival at Maungatautari (7 March from Tiritiri Matangi and 27 March from Little Barrier) the boxes of birds were carried into the forest of the southern sub-enclosure and released near the six supplementary feeding stations; food has been provided in these since the release.

Post-release monitoring: Monitoring is challenging due to the large forest area and rugged terrain, and use of natural nest cavities makes it is very difficult to locate nests and ring young. Consequently, the intensive monitoring methods undertaken on reintroduced hihi populations on small islands (Ewen & Armstrong 2007) could not be followed. Instead, we attempted to obtain an estimate of population size after one year, as suggested by Sutherland *et al*. (2010) as a minimal monitoring requirement for a reintroduced bird population. A 15-day survey was conducted under contract to Maungatautari Ecological Island Trust in February 2010 by an experienced observer (KR). Surveys comprised walking along bait lines (laid to record mammal presence) in such a way that there were no gaps greater than 500 m between areas traversed, such that the whole mountain was surveyed fairly evenly. Hihi calls were played approximately every 500 m (Philips Shoqbox mp3 player) in an attempt to attract any birds present in the area. Where hihi were heard an attempt was made to see them and record colour ring combinations or confirm presence of unringed individuals (i.e. juveniles produced during the first breeding season). The survey design consisted of six searches of the southern sub-enclosure, about 65 ha in area, over 3-days (i.e. 2 surveys/day, walking a different set lines on each occasion), and a single search of the remainder of the mountain over 12 days. Our rationale behind greater survey effort in the southern sub-

enclosure was to get the best possible estimate of detection probability by maximising the number of encounter occasions as we believed the majority of hihi may be located there based on the presence of feeders and *ad hoc* observations. The key assumption was that the probability of detecting a hihi during a single search of the southern sub-enclosure was similar to the probability of detecting a hihi on the rest of the mountain. We estimated detection probability (*p*) and number of individuals (*N*) under model M. (detection probability constant among searches and individuals) using the closed-captures procedure in Program Mark (White & Burnham 1999).

CONSEQUENCES

Capture, health screening and translocation: A total of 64 juvenile hihi were caught on Tiritiri Matangi. Individuals were in generally good body condition at capture (males 37.8 ± 0.5 g; females 31.2 ± 0.4 g). All passed the initial physical examination although ectoparasitic hippoboscid flies (Diptera, Hippoboscidae) were commonly seen (11% of birds). Bacterial culture from cloacal swabs failed to detect *Salmonella* or *Yersinia*. Estimated total WBC's ranged from 2.4 x 10 g/L and 51.8 x 10 g/L (elevated counts may be associated with aspergillosis or other previously unreported disease). In total five individuals were rejected from translocation, three females due to excessive weight loss and two due to high estimated total WBC's (1 male:1 female). Birds lost on average 0.4 ± 0.3 g during quarantine.

A total of 21 hihi were caught on Little Barrier Island (14 males and 7 females). Again individuals were in generally good body condition (adult and juvenile males 37.7 ± 0.9 g; adult and juvenile females 30.1 ± 0.5 g) and there was a high prevalence of hippoboscid flies (24% individuals). Bacterial culture from cloacal swabs failed to detect *Salmonella* or *Yersinia* and estimated WBC ranged from 3.9 x 10 g/L to 16.2 x 10 g/L. Only one bird was not translocated because of permit restrictions on numbers rather than any unusual health screening result. Birds gained on average 0.5 ± 0.8 g during quarantine.

Survival and breeding: MEIT volunteers and staff regularly sighted hihi between release and the February 2010 survey, and one nest was located in the southern sub-enclosure during the first breeding season. This breeding event comprised a Little Barrier female and (at least socially) two Tiritiri Matangi males. Observations suggest two clutches fledged (unknown number of fledglings) from this nest. Location of hihi observations, survival of birds from the two different founder populations, this breeding record and observations of juvenile birds resulting from the first breeding season subsequent to release, suggest cross-breeding of birds from the two founder populations (thus reducing the potential problem of inbreeding depression). During the 12-day survey outside the southern sub-enclosure, hihi were located in two sections of the mountain. Two juvenile unringed birds were sighted feeding on *Alseuosmia macrophylla* fruit on one day and a single juvenile (estimated fledged one week earlier) was sighted in the presence of an adult male and one other juvenile (both heard but not seen) on another.

A total of nine ringed hihi were sighted by KR during the 15-day survey in February 2010, eight in the southern sub-enclosure and one on the rest of the mountain. The estimated detection probability for the southern sub-enclosure based on closed mark-recapture was 0.14, giving a 0.63 probability of detecting an individual over the six searches. Based on this, the estimated number of ringed hihi was 19.2, consisting of 12.7 birds in the southern sub-enclosure (95% confidence interval 8.8-35.2) and 6.5 on the rest of the mountain (95% confidence interval 1.8-41.0) (Table 1). There were also *ad hoc* sightings of seven other ringed individuals in the southern sub-enclosure within the same period, meaning the number in the southern sub-enclosure was underestimated and the number of ringed birds was probably somewhere between 15 and 35. individuals. KR recorded 25 sightings of unbanded birds, thus showing successful breeding in the first year, but it is unknown how many of these were the same birds.

Table 1. Estimates of detection probability (*p*) and number of individuals (*N*) based on closed mark-recapture analysis of survey data collected at Maungatautari in February 2010. There were six searches of the southern sub-enclosure, allowing an estimate of detection probability, and a single search of the rest of the mountain.

Location	Parameter	Estimate	SE	Lower CI	Upper CI
Southern sub-enclosure	*p*	0.14	0.07	0.05	0.34
	N	12.73	5.21	8.83	35.16
Rest of mountain	*N*	6.48	7.34	1.75	40.98

Conclusions: Experienced personnel managed to capture the required number of hihi for the translocation very quickly, allowing more rapid health screening and shortened holding times in aviaries than in previous translocations of the species. Hihi appeared to settle well in aviaries, readily taking food and in general gained condition (increased weight) during this time. Given some birds were rejected for translocation (primarily for health reasons) it was worth initially capturing more individuals than required; this potential problem had been predicted.

Although post-release monitoring was limited to 15-days, it revealed some important facts about the initial establishment of hihi on Maungatautari. Firstly, many birds survived the initial release being recorded up to about one year post-release. Secondly there appeared to have been substantial successful breeding in the first breeding season, with sightings of unringed juvenile birds across the mountain. Finally, birds from both source locations survived and at least one breeding event comprised birds from both source locations, thus potentially reducing the problem of inbreeding depression. We encourage continued monitoring of this population to track its fate over the medium to long term. One focus of monitoring should be to determine dispersal from this mainland release site (a current management concern for mainland bird reintroductions of hihi and several other species) and to what extent this may compromise population growth.

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