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Re-introduction of shore skinks to offshore islands in the Auckland region, New Zealand

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Introduction

The shore skink (*Oligosoma smithi*; Gray, 1845) is one of two native lizard species that are restricted to the northern coastline of New Zealand (Hare *et al.*, 2008; Chapple *et al.*, 2009). Despite having a wide distribution on the mainland and on offshore islands in the northern part of North Island (Towns *et al.*, 2002; Hare *et al.*, 2008), this species is significantly impacted by introduced mammalian predators. In particular, several shore skink populations have shown marked increases in recruitment following pest eradications (Towns, 1991; Towns, 1996 G. Ussher, unpublished data), therefore they could be considered ideal indicator species for pest eradication projects. Shore skinks were selected as a target species for captive breeding for future translocations, as part of an ecosystem restoration approach for islands in the Auckland region. This endemic species is ideal for re-introductions due to their generalist foraging strategy, coupled with their relatively fast maturation period (M. Baling, unpublished data). Their visually active and diurnal behavior also serve as a good reptile conservation advocate to public visitors at island reserves. In 2006, the first translocation of this species was conducted to two offshore islands in the Hauraki Gulf, Auckland, and into captivity as a trial for breeding program that aims for future wild releases.

Shore skink release © D. Jenkins

Goals

- Goal 1: Promote a functional, self-sustaining ecosystem on offshore islands in the Hauraki Gulf, Auckland, by establishing new lizard species

populations that are currently absent in habitats within the species historic range.
- Goal 2: Create founder populations from captive-bred shore skinks for re-introduction projects as a means of reducing pressure on wild sources.
- Goal 3: Determine at source population recovery following removal of skinks for re-introduction.

Success Indicators

- Indicator 1: *Re-introduction sites* - Short-term: The survival, establishment and breeding of founders and their offspring at islands. Long-term: Self-sustaining populations that consist of island-born breeders on islands.
- Indicator 2: *Captive population* - Short-term: The survival, establishment and breeding of the founder population. Long-term: Yearly production and survival of offspring in captivity to the point of suitable re-introduction size, condition and health.
- Indicator 3: *Source population* - The continual increase in juvenile recruitment at all cohort stages, two years following removal of skinks.

Project Summary

Feasibility: The species re-introduction was initiated through discussions between Massey University (Albany Campus) and the New Zealand Department of Conservation (DOC), for the identification of reptile research and conservation management priorities in the Auckland region. These discussions and the identification of source and release locations later expanded to involve local councils, local herpetologists, captive breeders and veterinarians to develop best practice protocols. The selection of the source population was highly dependent on a large population size that was geographically closest to re-introduction locations. The two islands selected were surveyed for best release sites based on habitat type of the source population, to increase chances of survivorship. The enclosures at the captive facility are held outdoors and have naturalistic environment settings, to promote normal intra-specific interactions and breeding. The support from Massey University, Supporters of Tiritiri Matangi Inc. (SoTM), Motuora Restoration Society Inc. (MRS), Auckland Regional Council (ARC), DOC and local iwi tribes contributed to the translocation of 120 individual shore skinks from Tawharanui Regional Park (Tawharanui) to Tiritiri Matangi Island (n=30), Motuora Island (n=30) and the Massey University Captive Reptile Breeding Facility (n=40).

Implementation: The species re-introduction underwent several stages; initial survey and disease-screening of reptiles at release sites (Tiritiri Matangi and Motuora Islands), capture and quarantine of shore skinks from source site (Tawharanui), and the release of the animals to each site. Initial reptile surveys were conducted on both islands to confirm non-presence of the shore skink, in accordance with DOC protocols. Funding for disease-screening was limited, therefore only reptile-associated parasites of health concern were targeted; i.e. *Salmonella* and *Cryptosporidia*. A sample of reptiles from the release site islands and all of the captured shore skinks were tested for true positives. In November 2006, shore skinks were sourced at a female-biased sex ratio of 1:2, with a focus on capturing gravid females to provide immediate island-born individuals (due in January/ February 2007) and to increase genetic diversity of the founder population (through non-related founder neonates). All shore skinks were quarantined at the Massey University captive facility, and wildlife veterinarian advice was sought when some individuals tested positive for *Salmonella*. The translocation as deemed fit to continue, after results showed the presence of an uncommon strain of *Salmonella* at the release sites, and that all shore skinks were tested negative (except for one). The releases at both island reserves were public events, promoting public advocacy of reptile conservation and restoration by re-introduction.

Post-release monitoring: For each founder population was conducted intensively for the first four months, and then at three-monthly intervals until the end of 2008. Live-trap grids were used to monitor survivorship and distribution of each founder population. The distributions of two other resident skink species were also recorded to investigate niche displacement. Evidence of island-born individuals from translocated gravid females was first detected in early 2007, signaling initial founder survival and successful birthing. The following New Zealand summer season (2007-2008), young or sub-adults, including several gravid females in the trapping grid were caught at Tiritiri Matangi Island (confirming successful establishment). The second release site at Motuora Island was exposed to large winter storms and the population remained undetected (with the exception of one or two adults) during the summer of 2007-2008. This was possibly due to insufficient refuges from storms and unusually high tides during the winter months at the release site. Monitoring continues bi-annually and will be conducted by the volunteers of each NGO (SoTM and MRS), with guidance from the current researcher. Volunteers are trained to set the traps, identify species and data recording for monitoring long-term trends of the populations. The possibility of supplementation (to further increase genetic diversity) is likely for founder populations that are stable or have established and is part of the original translocation proposal.

Post-removal monitoring of the source population: This was conducted as part of a postgraduate student project that was examining the effects of mouse predation on the population recovery. The source population was monitored for one year, using live-traps within pest-controlled and non-pest-controlled grids from which the skinks were sourced. The study showed that the skinks remained abundant within both grids but particularly so within the pest-controlled site. Additionally, population recovery would likely be much greater within the pest-controlled site where the population comprised of a significantly greater proportion of juvenile skinks, despite both sites having similar proportions of neonates. The study suggested that a higher predation pressure on neonate skinks by mice in non-controlled sites is likely to suppress skink recovery rates. Because ongoing pest management occurs at Tawharanui, the population is capable of recovering post-translocation. The captive founder population was established and has been successfully breeding since 2007. All animals' conditions are monitored and their morphometrics recorded monthly. There is a high survival rate for captive-born young, and they are seen to be sexually mature by two years of age. In early

2009, 30 captive sub-adult (born season 2006-2007) and 50 wild-caught shore skinks were disease -screened and released to Motuihe Island, Auckland, as part of the island's restoration plan. This marked the first translocation from the captive breeding facility. The next cohort, born 2007-2008, is planned for release to Crusoe Island, Auckland, in early 2010 as part of the Auckland Regional Council's initiative.

Ocean Dunes TRP © C. J. Wedding

Major difficulties faced

- Unpredictable weather, especially heavy storms and high tides during winter that destroyed trap grids. Therefore trap maintenance can be very high.
- The difficulty in detecting this species at low densities, especially to capture newborn individuals. This facilitated the need for multiple capture/ tracking techniques (i.e. live pitfall traps, artificial refuges, funnel traps, tracking tunnels, and hand-capture) to increase detection rates.
- Due to the high cost and limited funding for disease-screenings, a comprehensive testing of both translocated individuals and release site populations were not able to be done. Priorities for potential diseases of concern had to be selected instead.
- Developing best practice husbandry techniques and data recording, while attempting to provide for and maintain natural behaviors (e.g. intra-specific competition, foraging) in the captive population without significant detriment to the survivorship of individuals.
- Conflict of interest in shore skink experiment on pest monitoring manipulations and other wildlife management. The pest-controlled grid at source population area is also the breeding ground for the endangered New Zealand dotterel (*Charadrius obscurus*), and some volunteers of Tawharanui raised concerns about the effect of rodent bait stations and skink trap placements on the chicks.

Major lessons learned

- Selection of suitable release sites particularly within dynamic habitat types such as beaches or close to the coastline that may change according to seasonal weather should be taken into account. Sufficient stable refuges should be identified, or added if there is little choice in release sites.
- Importance in communication (before, during and after the translocation) between DOC, ARC, local councils, NGO's, iwi tribes, and researchers is very high. Good communication is needed to maintain relationships, share local knowledge and aid in funding for research and monitoring. Teaching, training and educating volunteers in monitoring techniques is advisable to maintain

reliable long-term data collection that will assist the increase in local knowledge of the species and location.

- Defining disease-screening methods and understanding of *Salmonella* prevalence in New Zealand reptiles. There was a lack of standardized protocol in disease-screening New Zealand reptiles in the Auckland region.
- Setting the standard in quarantine procedures in reptile translocation in the Auckland region. This translocation procedure preceded the next few lizard re-introductions in the Auckland region, where advice and services were sought from researcher by other NGO's organizing other lizard translocations.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- One of the two wild-release populations has fulfilled the short-term goal of the re-introduction. The long-term goal will be assessed at five and 10 years post-translocation. This first lizard re-introduction to Tiritiri Matangi Island may be used as an example for future re-introduction of more endangered New Zealand lizard species to this public scientific reserve.
- The outcome for the shore skink re-introduction to Motuora Island is currently inconclusive due to low re-capture rates and will be re-assessed in the next two years.
- The captive population has satisfied the short and long-term goals, as young are born annually and high proportions are surviving to adulthood. These young are fit to be translocated to the wild, therefore will aid in restoring the historical geographic distribution of the species, and also complete island ecosystem restorations.
- The project confirmed the capability of a high-density source population to recover after removal of 120 individuals from the site.

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Changing taxonomy and the need for supplementation in the management of re-introductions of Brothers Island tuatara in Cook Strait, New Zealand

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Introduction

Tuatara (*Sphenodon*) are medium-sized reptiles and the sole extant representatives of the order Rhynchocephalia. Once widespread in New Zealand, tuatara were extirpated from the mainland after the introduction of mammalian predators ~700 years ago. Thirty-one small natural populations are currently found on isolated off-shore islands. Although the taxonomic history of tuatara is complex, two species have been recognized since 1990: the population on North Brother Island (*S. guntheri*, Brothers Island tuatara) and all other natural populations (*S. punctatus*, Cook Strait and northern tuatara). The New Zealand Department of Conservation lists *S. guntheri* as “Nationally Endangered”, and the IUCN lists it as vulnerable (D1 + D2). However, recent genetic data indicate that the species distinction of *S. guntheri* is unwarranted, and that all tuatara are best described as

Female tuatara outside burrow

a single species (Hay *et al.*, 2010). Here we provide an update on two re-introductions of *S. guntheri* in Cook Strait, New Zealand: Titi (1995, Nelson *et al.*, 2002) and Matiu/Somes Islands (1998, Merrifield 2001). We also report a third re-introduction to Long Island (2007). North Brother Island, which is within the same ecological region, was used as the source population, and mammalian predators were eradicated prior to each re-introduction.

Goals

- Goal 1: Secure the population viability and genetic diversity of tuatara (Gaze, 2001).
- Goal 2: Ensure survival of a unique species (*Sphenodon guntheri*) through re-introductions. This goal changed in 2009 as a result of changing taxonomy (see below). The revised goal is to represent the diversity of extant populations and key geographic variants.
- Goal 3: Increase public access to tuatara and education on tuatara conservation.

Success Indicators

- Indicator 1: The release of Brothers Island tuatara onto three predator-free island sanctuaries.
- Indicator 2: Survival and growth of founders within five years of release.
- Indicator 3: Evidence of reproduction within 10 years of release.
- Indicator 4: Increased conservation advocacy.

Project Summary

Feasibility: Titi (32 ha) and Long Islands (142 ha) are protected nature and scenic reserves; Matiu/Somes (24.9 ha) is a scientific and historic reserve that is accessible by public ferry and recreational boats. Matiu/Somes Island receives about 15,000 visitors annually, posing a significant threat of reinvasion by rodents from the mainland. Upon arrival, all visitors must pass through a quarantine station administered by the Department of Conservation rangers on the island. The quarantine procedure provides an opportunity to educate visitors on the threat of introduced mammals to tuatara and other New Zealand wildlife. The mammal eradications and tuatara re-introductions required support from local Māori (indigenous peoples of New Zealand) for each island.

Implementation: The populations on Titi and Matiu/Somes Islands were founded by wild adults and captive-reared juveniles (Titi: 18 adults and 50 juveniles, Matiu/Somes: 20 adults and 35 juveniles). The Long Island population was founded entirely by captive-reared juveniles (n=53). Tuatara were sourced directly from the wild and from eggs collected from females by induction of oviposition and directly from nests on North Brother Island in 1989-1991 and 2000-2001. Eggs were hatched at Victoria University of Wellington, and juveniles were reared in semi-natural conditions in captivity at Nga Manu Nature Reserve (Titi and Matiu/Somes Islands) and the Wellington Zoo (Long Island) until release at 3-6 years of age. Tuatara were marked with unique toe-clips for identification, individually packaged in aerated poster tubes, and transported by helicopter and boat to the islands. Artificial burrows (~50cm long under vegetation) were constructed prior to re-introduction to provide a safe place to release animals. Burrows were installed on Titi and Matiu/Somes Islands by excavating soil and installing a ~1m drainage pipe; on Titi Island, this drainage pipe connected to a wooden box with a lid to facilitate monitoring. On Long Island, burrows were excavated, but the plastic drainage pipe was not used.

Post-release monitoring: The population on Long Island has not yet been formally monitored, but several individuals have been seen during informal visits. The populations on Titi and Matiu/Somes Islands were both monitored intensely in the two years following re-introduction. Titi Island was also monitored 3, 5, and 11 years after re-introduction, and Matiu/Somes was also monitored 6, 7, and 9 years after re-introduction. The most recent monitoring event was in 2007 for both populations; 185 and 195 person hours were spent searching for tuatara on these trips (Titi and Matiu/Somes Islands, respectively). On each monitoring trip, the habitat was searched thoroughly and all tuatara encountered were caught by hand. All captured tuatara were measured for body size (snout-vent length, SVL in mm) and mass (g). Over all monitoring trips, 43 of 68 founders (63%) were captured on Titi Island, and 33 of 55 founders (60%) were captured on Matiu/Somes Island. Four of the animals on Titi Island and three on Matiu/Somes Island captured in 2007 had not been captured since release, indicating that more tuatara are likely to have survived the re-introductions but have not been located. Their cryptic appearance and difficulty searching the habitat (forest, fern thickets, penguin and seabird burrows, and cliffs) make it difficult to thoroughly search all habitat. Tuatara have dispersed from release sites to other areas of the islands, but many of the juveniles were located close to their release areas.

All founders have increased in size (SVL and mass) since re-introduction. Adults which were observed to show no growth in the eight years prior to re-introduction on North Brother Island, increased in size and continued to grow for at least 9-11 years after release ($p < 0.001$ for all SVL comparisons of individuals pre- and post -translocation, repeated measures ANOVA). Tuatara are generally in very good body condition. Animals released as juveniles on Titi and Matiu/Somes Islands have shown growth comparable with captive juveniles; some have reached a comparable size to adults in the source population, although it is unclear if this reflects sexual maturity. Reproduction was confirmed in 2007 on Titi Island with the capture of an unmarked juvenile adjacent to the adult release area, and on Matiu/Somes with the discovery of a nest. The nest location was close to a public-access track, so the two viable eggs were taken off the island and incubated at Victoria University of Wellington. Hatchlings were released back onto the island within 3.5 months of hatching.

Major difficulties faced

- Monitoring was challenging, because recapturing animals (particularly small and cryptic juveniles) in dense scrub habitat limited the ability to detect survival and growth of all founders on any single monitoring trip.
- Three factors make it difficult to asses the long-term viability of the re-introduced populations. First, the extreme longevity (100+ years) and large generation interval of tuatara (~40 years) make it difficult to interpret short-term

successes and gauge long-term success. Founding populations with only juveniles creates an additional 'lag time', as it will take several years for the founders to reach sexual maturity (maturity at ~14 years). Second, we are unable to evaluate the effects of small population sizes and losses of genetic diversity (e.g. inbreeding depression) in the source and re-introduced populations because of difficulties in capturing animals (particularly juveniles) and their longevity. If populations are founded with only juveniles, higher pre-reproductive mortality rates could reduce the number of genetic founders. Third, recent data suggest that reproductive skew in tuatara is high (up to 70% of males do not mate across multiple seasons, Moore *et al.*, 2009). Models show that in these cases, at least 70 adult tuatara (or more juveniles) should be released in the founder group to ensure that genetic targets for management are met over 10 generations (Miller *et al.*, 2009). Based on this recent information, the long-term maintenance of genetic diversity (both relative to North Brother Island and other natural tuatara populations) has become an indicator of success for re-introductions.

- We have had to re-evaluate the re-introductions of Brothers Island tuatara in light of more recent data. Historically high levels of inbreeding and kinship on North Brother Island are likely exacerbated by the re-introductions. Further, recent genetic research indicated that all tuatara are best described as a single species (Hay *et al.*, 2010). This changing taxonomy, combined with small founder groups and low genetic diversity on North Brother Island, calls into question the validity of North Brother Island as a source population for re-introductions (whereas previous knowledge indicated that it was a desired source to secure a separate species).

Major lessons learned

- When re-introduced to predator-free island sanctuaries, founder survival and growth provide an indication of short-term demographic success.
- Each monitoring event results in the capture of founders that have not been seen since re-introduction. Therefore, data from multiple monitoring events are likely to provide the best indication of short-term successes.
- Changes to taxonomy may alter priorities for conserving populations and our evaluation of single populations as ideal or poor choices as source populations for re-introductions. Based on the most recent genetic information, North Brother Island is likely a poor choice of source population. Supplementation of released populations with tuatara from a wild population with high levels of genetic diversity and within the same ecological region would be desirable for long-term management.
- Goals for a re-introduction program and the indicators of success may change as new information becomes available.
- Long-term (e.g. 10 generations) goals for genetic diversity are important to consider at the time of release, based on species biology.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Three re-introduced populations were founded from North Brother Island, all of which are secure from introduced predators in protected reserves. One of these populations (Matiu/Somes Island) is readily accessible to the public without a permit. This re-introduced population is a successful tool for conservation advocacy, as thousands of visitors are educated annually on threats to tuatara annually.
- Growth and survival of individuals and reproduction were detected in the two populations that have been monitored for ~10 years.
- The survival of recruits and whether the re-introduced populations have a positive growth rate is unknown. The founder contributions cannot be evaluated until a large number of island-born animals are detected. It is possible that a high degree of reproductive skew in the founder groups will lead to rapid increases in inbreeding and losses of genetic diversity. Further, the effects of inbreeding cannot be determined, as it is not currently possible to evaluate individual reproductive success in the wild.
- The criteria for and indicators of success needed to be re-evaluated in light of the most recent taxonomic information. Whilst the re-introduced populations appear successful in the short-term, these populations now seem to be of lower conservation value. Success in the long-term is constrained, as re-introduction constitutes a demographic and genetic bottleneck in a historically small population.

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Re-introduction of the Antiguan racer to offshore islands of Antigua, West Indies

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Introduction

The Critically Endangered Antiguan racer (*Alsophis antiguae*: Colubridae) was historically distributed throughout Antigua (280 km^2) and probably Barbuda (161 km^2). Henry W. Parker first described this snake in 1933, but declared it extinct three years later, purportedly due to the introduction of Asian mongooses (*Herpestes javanicus*). In 1989, Antiguan racers were rediscovered on Great Bird Island, a mongoose-free 8 ha islet, 2.4 km from Antigua's Northeast coast. A study by the first author found only 50 individuals remaining, half of which had injuries consistent with bites by alien rats (*Rattus rattus*). This finding prompted the formation of the Antiguan Racer Conservation Project by local and international organisations, which eradicated the rats from Great Bird Island. Within two years, the racer population had more than doubled in size (Varnham *et al.*, 1998). To enable the world population to increase further, a re-introduction program was launched in 1999 (ARCP, 1999), using wild stock from Great Bird to repopulate islands cleared of rats and mongoose. By 2010, more than 500 Antiguan racers inhabited four islands totalling 63 ha. While the islands are within a marine protected area, the racer lacks adequate legal protection and remains seriously threatened by alien species and human pressures (Daltry, 2007).

Antiguan racer © Matthew Morton, DWCT

Goals

- Goal 1: Suitable re-introduction sites within the Antiguan racer's historic range identified and alien invasive predators (rats and mongooses) eradicated.
- Goal 2: The support of local stakeholders and policy-makers secured through education, awareness-raising and consultations.

- Goal 3: Breeding colonies of Antiguan racers established on predator-free islands and form a viable meta-population.
- Goal 4: All Antiguan racer colonies adequately protected from threats and routinely monitored.

Success Indicators

- Indicator 1: Individual racers translocated from Great Bird Island to re-introduction sites exhibit higher rates of growth and survival.
- Indicator 2: Antiguan racers confirmed to be reproducing on all re-introduction islands within three years of release.
- Indicator 3: All islands inhabited by Antiguan racers protected and kept free of alien invasive predators.
- Indicator 4: Local stakeholders demonstrate positive commitment to conserving Antiguan racers and their habitat.

Project Summary

Feasibility Stage: Studies of the racer's population status and behavioural ecology began in 1995, using radiotelemetry, mark-recapture and direct observations (Daltry *et al.*, 2001). This medium-sized (snout-vent length to 105 cm) diurnal colubrid was found to prey almost exclusively on lizards (*Anolis wattsi* and the endemic *A. leachi, Ameiva griswoldi,* and *Sphaerodactylus elegantulus*). Antiguan racers are capable of reproducing from two years of age, and can live more than 15 years, but population turnover is high, with an annual age-independent mortality rate of 44%. Antiguan racers can achieve densities of up to 20 individuals per ha in the absence of alien mammals. Antigua has approximately 30 low-lying offshore islands ranging from less than 1 ha to 200 ha. Most, including Great Bird Island, are naturally vegetated with xeric woodlands, with white sand beaches and extensive areas of exposed limestone pavement. The only native mammals are bats, and the most conspicuous vertebrates are lizards and birds, including globally significant seabird colonies. All but the smallest islands had been invaded by alien black rats (*Rattus rattus*), which attack small snakes and degrade their habitat. The members of the Antiguan Racer Conservation Project (Forestry Unit, Environmental Awareness Group, Durrell Wildlife Conservation Trust, Fauna & Flora International, Island Resources Foundation and Black Hills State University) therefore concluded the rats should be eliminated from all prospective racer re-introduction sites (ARCP, 1999).

Antigua's offshore islands include both crown land and private islands, some of which have been developed for luxury housing. Tens of thousands of people visit the uninhabited islands on private vessels and tourist catamarans, with Great Bird Island and Green Island being the most popular for recreation. In 2006, seven years after the re-introduction program began, every island mentioned in this article was gazetted as part of the North East Marine Management Area, a multiple-use marine protected area. At the time of writing, however, this area still lacks regulations or staff on the ground. In the mid-1990s, few Antiguans knew of the racer's existence and most expressed a negative attitude towards snakes. To give the re-introduction program a chance of success, it was important to popularise the racer, especially among the private land owners, tour operators

Donald Anthonyson, Jenny Daltry and friends releasing racers on York © Tom Aveling, FFI

and other regular users of the islands. The Environmental Awareness Group (national NGO) and the Forestry Unit (Ministry of Agriculture, Lands, Housing and Environment) led the education efforts and dialogue with the many stakeholders. In addition to organising numerous public talks and field trips to Great Bird Island, project personnel visited schools throughout Antigua to display live racers and developed several documentaries about the project, articles in newspapers and magazines, postings on the Internet, radio interviews, and tour operator training workshops. Public knowledge and opinion of the racers improved significantly, and the project team gained permission to re-introduce the species even to private islands (notably Green and York, owned by the Mill Reef Club). In 1999, the IUCN/SSC Re-introduction Specialist Group formally endorsed a plan from the Antiguan Racer Conservation Project, which presented these issues in more detail (ARCP, 1999).

Implementation Stage: Between 1995 and 2008, rats and, where present, small Asian mongooses were eradicated from 12 islands using brodifacoum bait (Varnham *et al.*, 1998). Islands were selected based on their potential suitability for snake re-introductions or to reduce the risk of re-introduction sites being reinvaded. The first re-introduction of Antiguan racers took place on Rabbit Island (2 ha) in 1999, followed by Green Island (45 ha) in 2002 and York Island (7 ha) in 2008. In all cases, young racers were observed within two or three years of the first release, confirming that the snakes had bred. To combat inbreeding, additional stock are periodically taken from Great Bird to the re-introduction sites. All source animals were translocated from Great Bird Island, where the population had attained its carrying capacity of between 100 and 160 adults and subadults. No more than 10% of the source population was removed in any one year, and the closely-monitored source population has remained consistently high. All translocated individuals were tagged and a sliver of tissue removed from the tail for genetic analysis. The snakes were transported by boat from Great Bird to the re-introduction sites, typically within less than 24 hours of capture. Only adult and subadult snakes in peak physical condition were translocated.

Post-release monitoring: This was done using radiotelemetry and direct observations which have revealed that the translocated racers adapted easily to the new islands and exhibit growth spurts when released from the competitive

Green Island - the largest re-introduction site
© Jenny Daltry, FFI

environment on Great Bird Island. Almost every year, a census lasting approximately 40 days is conducted by project staff using a standardized mark-recapture method (Daltry *et al.*, 2001). All captured racers are marked with a unique PIT tag. The total population exceeded 500 adults and subadults in 2010, a ten-fold increase since the project began. Populations of the racer's main prey species – *Anolis wattsi* and *Ameiva griswoldi* – have also been the subject of intensive field-based investigations (e.g., Smith & Colbert, 2002). As the racer populations have increased on each island, the lizard populations have appeared to dip slightly, but not significantly. Threats to the racers are being monitored, especially the presence of alien invasive species and the number and impacts of human visitors to the offshore islands. Since 2002, a network of rat-bait stations has been maintained and monitored on each re-introduction site to provide an early warning of any re-invasions by rats. Contingency supplies of rodenticide are maintained in Antigua to allow a rapid response in the event of a reinvasion. The project partners meet annually to evaluate progress and decide upon future goals.

Major difficulties faced

- Initially, most people who own or use the offshore islands regarded snakes as vermin. The project had to invest heavily in nationwide education and awareness programmes to ensure local stakeholders would not kill the snakes or oppose the re-introduction.
- The source population on Great Bird Island, which was probably isolated for hundreds of years, exhibits many signs of inbreeding. This raises questions over whether any of the re-introduced populations will be genetically viable over the long term.
- Alien invasive species - notably the black rat (*Rattus rattus*) and fire ants (tentatively identified as *Wasmannia auropunctata*) remain a significant threat to all islands occupied by racers, and are difficult to control.
- The ever-increasing numbers of visitors and vessels increase the risk of alien invasions as well as increased human-snake encounters, habitat degradation and increased fire risk. The annual number of visitors to the 8 ha Great Bird Island, for example, has increased from 17,000 (mid-1990s) to well over 40,000.
- Securing sufficient funding to maintain the project remains a perpetual challenge. There may be potential to charge fees to recreational visitors who

use the marine protected area to help support essential protection and conservation activities.

Major lessons learned

- The Antiguan racer re-introduction program was grounded in a sound scientific understanding of the behaviour and population dynamics of the target species and its prey.
- The fact the program was operated by a consortium of organisations, rather than one body, gave it resilience. Wherever a partner was unable to contribute sufficient human or financial resources, the other partners worked harder to keep the program going.
- The re-introduction program benefited from being embedded in a wider, holistic landscape conservation program (the Offshore Islands Conservation Program) that addresses the management and sustainable use of the offshore islands.
- The use of relatively small offshore islands makes the eradication of introduced predators feasible. Preventing the reinvasion of re-introduction sites by rats is a perpetual challenge, and requires dedicated personnel and continuous funding streams to be sustained.
- The use of multiple re-introduction sites (islands) to establish a meta-population has made the target species more secure from stochastic impacts on individual sites.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Breeding colonies have been successfully established on all three islands to which the Antiguan racers have been re-introduced. and there has been at least a ten-fold increase in the global Antiguan racer population.
- Introduced predators were successfully eradicated and prevented from reinvading multiple sites.
- The Antiguan racer, and the re-introduction program, has met with strong support from key stakeholders, and local capacity to sustain the program has been significantly increased.
- The current sum of four populated islands is still short of our original target of five islands, however, and there is a lack of additional islands that appear suitable for re-introduction.
- None of the four islands can by themselves support a genetically viable population (numbering in the thousands). The future survival of this meta-population is therefore dependent on concerted protection and the assisted transfer of individuals between islands.

Acknowledgments
The Antiguan Racer Conservation Project forms part of the Offshore Islands Conservation Program co-managed by the Forestry Unit (Ministry of Agriculture, Lands, Housing and Environment), Environmental Awareness Group, Durrell Wildlife Conservation Trust, Island Resources Foundation, Fauna & Flora International and Black Hills State University. The authors thank everyone who have contributed their valuable time to planning, implementing and monitoring the Antiguan racer re-introduction program over the years, including Chrissundra Abdool, Mike Appleton, Steve Ashton, Tom Aveling, Calvin Balagne, Jahmilla Baptiste, Quentin Bloxam, Sophia Browne, Kevin Buley, Mykl Clovis, Dr Brian Cooper, Gillian Cooper, Lena Dempewolf, Kim Derrick, Winston Downes, Kevin Drew, Calvin Fenton, Joanne Ford, the Fuller family, Dr. Stephen Funk, Dr Gerardo Garcia, Carole-Faye George, Collie Gardner, Richard Gibson, Algernon Grant, Jervaine Greenaway, Harmony Hall, John Hartley, Leslie Henry, McRonnie Henry, Milly Iturra, Dr Karron James, Philmore James, Victor Joseph, Florita Kentish, Ian Kisson, Dr Jason Kolbe, Ato Lewis, Kevel Lindsay, Trisha Lovell, Cortright Marshall, Carole McCauley, Sarah McIntyre, Sean Mendonca, Lucia Mings, the Mill Reef Club, Dr Reg Murphy, Aldrick Nicholas, Lia Nicholson, Anantha O'Dean, Agnieszka Ogrodowczyk, Andrea Otto, Sean Peters, Polly Phillpot, Kohylah Piper, Junior Prosper, Kumarie Ram, Toby Ross, Dr Brian Smith, Nate Stephen, Ingrid Sylvester, Adriel Thibou, Kim Walter, Everette Williams, Dr Kevin Wright and Karen Varnham. Fieldwork and the preparation of this manuscript were supported by British Airways Assisting Conservation, Balcombe Trust, Disney Worldwide Conservation Fund, Durrell Wildlife Conservation Trust, Fauna & Flora International, Curtis and Edith Munson Foundation, Organization of American States, US Fish and Wildlife Service (grant 96200-9-G292), and Whitley Award Scheme. The rat eradication work described in this paper was made possible with the kind support of Syngenta Agrochemicals.

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Trial re-introduction of the woma python in northern South Australia

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Introduction

The woma (*Aspidites ramsayi*) are large (~2m), brown terrestrial pythons that are endemic to the arid and semi-arid parts of Australia. Womas occur in a wide range of sand dune and sand plane habitats (Tyler *et al.*, 1990; Cogger, 2000). Despite their size, womas are inconspicuous and rarely seen because they are primarily nocturnal, living in mammal burrows during the day. Mammals, reptiles and birds are the main prey of womas. Womas are endangered in eastern Australia and vulnerable in South Australia. Womas are critically endangered in south-western Western Australia (Cogger *et al.*, 1993), where habitat clearance is considered their greatest threat and where they have not been seen since 1980. Introduced cats (*Felis catus*) and foxes (*Vulpes vulpes*), which have driven many Australian mammalian prey species of womas to extinction or into serious decline in southern parts of the Australian arid zone (Johnson, 2006) probably also threaten womas by direct predation, particularly of juveniles.

Goals

- Goal 1: A trial re-introduction of woma pythons using available captive-bred stock, as a preliminary to a full-scale re-introduction ensuring appropriate genetic diversity (Read *et al.*, in press).
- Goal 2: To investigate the ecology, behavior and threatening processes of an inadequately studied locally (and potentially nationally) threatened species.
- Goal 3: To introduce a native predator to assist in population regulation of re-introduced mammals within the fenced portion of the Arid Recovery Reserve.
- Goal 4: To develop protocols for possible future breed-and-release programs of other endangered Boid snakes, in particular the critically endangered south-western Australian population of the woma.
- Goal 5: To increase public awareness of conservation issues.

Success Indicators

- Indicator 1: Clarification of disease-free status of captive-bred womas particularly with regard to ophidian paramyxovirus and inclusion body disease.
- Indicator 2: Recovery and successful feeding of womas post surgical insertion of transmitters.

- Indicator 3: Release of captive bred woma pythons into the Arid Recovery Reserve under two experimental conditions of food availability.
- Indicator 4: Collection and analysis of movement, habitat use, diet and causes of mortality of radio -tracked woma pythons.
- Indicator 5: Survival of released snakes over 12 months with a decline to no less than 60% of their pre-feeding release weight.
- Indicator 6: Attention from print, radio and television media, and public attendance at pre-release community meetings and presentations.

Woma python (*Aspidites ramsayi*) © T. Morley

Project Summary

Feasibility: The Arid Recovery Reserve is a 60 km^2 fenced exclosure in northern South Australia (S 30.4844, E 136.8833) from which all introduced rabbits (*Oryctolagus cuniculus*), cats and foxes have been removed. The reserve lies within the known historical natural range of womas, but no womas have been recorded within the reserve since it was established in 1997, despite weekly monitoring. The recovery of native mammal populations at the Arid Recovery Reserve has occurred due to natural increases following removal of introduced mammals, and the successful re-introduction of four locally-extinct, herbivorous and omnivorous mammal species. In addition to developing a re-introduction protocol to improve the conservation status of womas, introduction of a native predator was an appropriate management initiative to limit bourgeoning mammal populations within the Arid Recovery Reserve (Read & Johnston, 2005). Ten womas from a single clutch were bred at Adelaide Zoo from wild-caught parents. We considered regional provenance to be important because womas show considerable geographic variation in morphology. The parents of the released womas were wild caught within 400 km of the release site. Miniature radio-transmitters were surgically implanted into the gut cavity between 3rd and 5th April 2007. All snakes fed and sloughed their skin at least once following transmitter insertion before they were released. Prior to the release, the incidence of endemic parasites and potential pathogens was investigated in reptiles from the Arid Recovery Reserve. All womas identified for release were held in isolation from all other reptiles from May 2004 until they were released in September 2007. During this time they exhibited no symptoms of disease. Particular attention was paid to the possibility of ophidian paramyxovirus or inclusion body disease. All released snakes were negative for DNA tests for paramyxovirus.


Mulga snake predating on a woma © Chris McGoldrick

Implementation: Ten womas were transported from Adelaide Zoo to Roxby Downs on 21st September 2007. One of the 10 transmitters failed prior to release, so this individual was returned to Adelaide Zoo. The remaining nine womas (7:2) were either hard-released (4 males:1 female) directly in to the Arid Recovery Reserve or soft-released (3 males:1 female) into a 0.5 ha pen within the Reserve into which weed-free oats were spread weekly for five weeks before the release to encourage high rodent densities. Womas in the hard release group were placed at separate locations (at least 150 m apart) on dunes within 2.5 km of the release pen. Each woma was released next to a disused bilby burrow on the morning of 22nd September 2007.

Post-release monitoring: Following release, the womas were radio-tracked daily to determine their location, habitat, health, and details of retreats used. We deliberately located snakes at different times of the day to maximize the temperature and diurnal range of observations, but found that we were not able to locate nocturnal fixes with precision or confidence without potentially damaging the snake refuges. Therefore most radio-tracking was conducted during daylight hours. Following an initial sedentary period, the womas moved shelters every five days, or so. Individual womas travelled up to 230 m. The womas released into the 'soft release' pen moved out of the pen within two weeks. All womas were found within or just outside underground retreats, usually burrow or warrens, during daylight hours. Successful feeding was confirmed for several of the released womas. The most noteworthy outcome of the study was that all released woma pythons were killed within four months, most likely by mulga snakes (*Pseudechis australis*).

Major difficulties faced

- Assessing disease status of captive bred woma pythons, specifically with regard to ophidian paramyxovirus and inclusion body disease. Both diseases were confirmed in captive reptile collections in Australia just prior to instigation of the re-introduction program. No testing facilities in Australia. This testing took over two years.
- Long-term captive husbandry required due to delays in assessing disease status of captive bred woma pythons.
- Unexpected predation by mulga snakes, which were not identified as an important predator during planning stages of the trial re-introduction.

Major lessons learned

- Allow sufficient time for pre-release assessment of disease status in the face of emerging diseases for which diagnostic tools are being developed.
- Womas easily and rapidly scaled the netting fence designed to contain them within the soft-release experiment
- Expect to be surprised, even in areas where you have long experience of the fauna and natural history. Predation by mulga snakes was not predicted to be a major source of mortality prior to the release.

Habitat at the Arid Recovery Reserve site trial re-introduction © Terry Morley

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Trial release achieved, snakes fed and found shelter, although all released snakes were predated within four months.
- New information obtained about the ecology, behavior and threatening processes that will inform future re-introductions of woma pythons.
- Public awareness of conservation issues increased through considerable media attention and public attendance at pre-release community meetings and presentations

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Welfare release of Babcock's leopard tortoise, KwaZulu-Natal, South Africa

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Introduction

The options available for tortoises in rehabilitation centres are a life-time in captivity, euthanasia or release. However, in South Africa, there are not enough suitable tortoise sanctuaries, and rehabilitation centres are reluctant to euthanize tortoises because this is contrary to their aims. As a result, tortoises are released into the wild without reference to a documented release protocol and with no consistent post-release monitoring. We released Babcock's leopard tortoise (*Stigmochelys pardalis babcocki*), not internationally red-listed, as this tortoise is the most frequently admitted to a large rehabilitation centre in the KwaZulu-Natal province (KZN).

Leopard tortoise with transmitter

Since only the subspecies *S. p. babcocki* can be released in KZN, various morphological indicators were used to separate it from *S. p. pardalis*, and from putative hybrids of the two subspecies. Even though many authors do not recognize the two subspecies (e.g. Boycott & Bourquin, 2000), there is genetic evidence to suggest that there is a difference (e.g. Le *et al*., 2006). Release areas had to be on private land in KZN, as releases are not permitted in state protected areas. We published results of our release study in Chelonian Conservation and Biology (Wimberger *et al*., 2009), which has been reprinted here with permission.

Goals

- Goal 1: To test the efficacy of a tortoise release protocol developed using the IUCN Re-introduction Guidelines by a

provincial conservation authority, Ezemvelo KwaZulu-Natal Wildlife (EKZNW), to increase the probability that the release of rehabilitated tortoises would be successful while minimizing risks to biodiversity.
- Goal 2: To provide the first documented post-release monitoring of rehabilitated South African tortoises.
- Goal 3: To determine whether rehabilitated *S. p. babcocki* could be successfully released into the wild (Wimberger *et al*., 2009).

Overview of tortoise habitat

Success Indicators
- Indicator 1: Survival of released tortoises.
- Indicator 2: Site fidelity.
- Indicator 3: Causes of death, whether natural or as a result of other factors (e.g. not adjusting to release) (Wimberger *et al*., 2009).

Project Summary
We chose two sites for release, the 913 ha Leopard Mountain Game Reserve (GR) and the 2,196 ha Usuthu Gorge Community Conservation Area (CCA), in north-eastern KZN. Both locations contained suitable habitats for leopard tortoises, and at least some of the leopard tortoise's preferred food plants, refuge sites and water. Both reserves had *S. p. babcocki*, and the reserves were within the historical range of the species. The number of tortoises in the reserves was unknown but likely to be below carrying capacity. This was due to a recent severe drought in the region of Leopard Mountain GR, and surrounding areas having recently been converted from cattle farms to a consolidated wildlife conservation area, while the Usuthu Gorge CCA was in the process of becoming established as a community conservation area. Previously, high tortoise mortalities were likely on the release areas and surrounding land because of the use of tortoises for food, and from being burnt during uncontrolled fires or during fires designed to promote livestock production as opposed to wildlife conservation (Boycott & Bourquin, 2000).

As tortoises are killed by vehicles while crossing roads (Boycott & Bourquin, 2000), it was important that neither release areas had tarred roads (which promote greater traffic flow and higher traffic speeds), and only Leopard Mountain GR had a district road passing through it, which was used mainly by reserve vehicles and vehicles of tourist clients entering or exiting the reserve. The release program was understood, accepted and supported by the neighbouring landowners and local communities.

Tortoises were selected for release if they had greater than 100 mm carapace length, had been at a rehabilitation center for longer than two months, and were deemed medically fit for release by a herpetologist. Besides one tortoise (confiscated from the traditional medicine trade), most of the *S. p. babcocki* were escaped pets, as they would not naturally be found in the suburbs of the city of Durban or in that region, and most had distorted carapaces (e.g. pyramiding of scutes). In January 2005, 22 *S. p. babcocki* (5 males and 5 females with radiotransmitters attached) were hard released into the Leopard Mountain GR. In December 2006 and February 2007, 7 (2 males and 5 females with radiotransmitters attached) *S. p. babcocki* were hard released into the Usuthu Gorge CCA. Post-release interventions included returning those tortoises that we detected as having moved from the fenced reserves to ensure that we could relocate the tortoises through the study and to prevent the tortoises from being exposed to greater threats than might occur on the patrolled areas during the study. We realized that some of the tortoises might disperse again later, but we hoped that by returning them they might settle down in the release areas (as this has been done in some tortoise relocation studies, e.g. Tuberville *et al.*, 2005), or else that by the end of the study the tortoises would be more familiar with the habitat of the region. Furthermore, if any of the released *S. p. babcocki* showed signs of disease, it was taken to a veterinarian to be treated.

The 10 radio-telemetered tortoises released at Leopard Mountain GR were located monthly for the first 10 months after release, and sporadically (maximum five times) up to 25 months after release. A radio-telemetered wild tortoise was located monthly (after affixing the radio-telemeter), until the telemeter was found detached on the ground. Due to malfunctioning of some of the radio-telemetry equipment, not all radio-telemetered tortoises were found at each monitoring session. Non-telemetered tortoises were located opportunistically. Tortoises released at Usuthu Gorge CCA were located monthly for up to 13 months, when the study ended. A 3-tier Yagi aerial and a wide-range receiver were used to locate the radio-telemetered tortoises. Once found, their locations were obtained using a Global Positioning System. By the end of the study, one of the tortoises was returned to captivity because of disease, four were killed intentionally or accidentally by humans, three others died due to a combination of disease, starvation and/or dehydration, and the fate of six were unknown. Due to known failure of two radio-telemeters, it was the likely cause of the disappearance of the other tortoises. Two tortoises were known to survive 13 months after release at Usutu Gorge CCA and one tortoise was known to survive 25 months after release at Leopard Mountain Game Reserve (Wimberger *et al*., 2009).

Major difficulties faced

- Lack of comprehensive disease checking protocol for implementation before release to ensure all life-threatening and transmittable diseases were detected and cured before release.

- Large numbers of leopard tortoises, which have large spatial requirements, in rehabilitation, with no space for them at these centers.
- Diseases easily spread amongst tortoises in captive situations. Was captivity the origin of the diseases whose symptoms were displayed by some of the released tortoises?
- Identification and fate of putative hybrids. Sterilization of males is easier than in females, so does that mean we only release sterilized males and euthanize the females?

Radio-tracking released tortoises

- Knowledge of the origin and history of the tortoises. A large number could be ex-pets. Post-release survival could depend on the time kept in captivity as a pet (absence of survival behavior in the wild (e.g. brummation in winter)) and perhaps on what they were fed as a pet.
- Education of the public in order to persuade them not to keep leopard tortoises illegally as pets, especially if the tortoises are found in the wild. The education programs implemented previously have not stopped the illegal keeping of tortoises in captivity.
- Human threats to released tortoises, namely poaching and collisions with vehicles.
- Dispersal from release sites, and leaving the secure areas.

Major lessons learned

- A high survival of released rehabilitated tortoises cannot be assumed.
- Thorough disease checking by a veterinarian is vital before any rehabilitated tortoises are released.
- Where possible and practical, placing rehabilitated *S. p. babcocki* in an enclosure for a period before release may help to increase site fidelity (Tuberville *et al.*, 2005), may allow susceptibility to the diseases present at the release site to be manifest and for latent diseases from captivity to reveal themselves (Dodd & Siegel, 1991), and may allow the tortoises to adapt to eating the indigenous vegetation in the area.
- Reserve fencing should be properly secured to prevent tortoises from pushing through.
- Rehabilitated *S. p. babcocki* should not be released in precipitous landscapes as rehabilitated tortoises may not be as fit as wild tortoises due to their time in captivity.
- If possible, release areas should not have public roads traversing them.

Translocation of Duvaucel's geckos to Tiritiri Matangi and Motuora Islands, Hauraki Gulf, as part of island ecological restoration initiatives.

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Introduction

Duvaucel's geckos (*Hoplodactylus duvaucelii*) are New Zealand's largest extant gecko reaching total lengths of 320 mm (160 mm snout-vent length [SVL]) and weighing up to 118 g (Gill & Whitaker, 1996). They are an important component of forest ecosystems, providing ecological roles as predators, prey, pollinators, and seed dispersers (Whitaker, 1987). Sub-fossil evidence and their present discontinuous geographical distribution suggest that *H. duvaucelii* were once widespread across New Zealand, however the combined effects of habitat degradation and introduced mammalian predators have confined this species to 36 isolated island populations (Towns, 1991). *Hoplodactylus duvaucelii* are listed under Category 6 ('At Risk-Naturally Uncommon', Human Induced) by the New Zealand Department of Conservation Threat Classification System (Hitchmough *et al*., 2007). This category includes all species that occur within typically small and widely scattered populations. The IUCN Red List classifies *H. duvaucelii* as 'Lower Risk'/ 'Least Concern' with its history insufficiently known (Groombridge, 1994). Tiritiri Matangi (220 ha) and Motuora (80 ha) Islands are protected sanctuaries and are currently undergoing ecological restoration by way of re-vegetation and faunal re-introduction programs. These islands were considered ideal candidates for the introduction of *H. duvaucelii* populations.

Gecko with backpack transmitter © D. van Winkel

Goals

- Goal 1: Re-establishing a functional ecosystem on Tiritiri Matangi and Motuora Islands, which involves restoring the herpetofaunal communities to those of pre-human times; a component of which is the successful establishment of a breeding population of *H. duvaucelii* through translocation.
- Goal 2: Describing the first year post-release responses of *H. duvaucelii* to unfamiliar environments. Information will also be used for the management of future lizard translocations.
- Goal 3: Establishing long-term, volunteer-driven monitoring programs to evaluate *H. duvaucelii* establishment and breeding on Tiritiri Matangi and Motuora Islands.

Success Indicators

- Indicator 1: Recapture at least 50% of founders within three months of release.
- Indicator 2: Record evidence of island-born juveniles (offspring of released gravid founders) within one year of the release.
- Indicator 3: Provide evidence for successful recruitment by recording successive generations of offspring and survival of cohorts to adulthood.
- Indicator 4: Show the extent of dispersal and population expansion by capturing individuals outside of the release site.
- Indicator 5: Provide evidence of a self-sustaining population, with a greater proportion of new island born geckos captured compared with original founders.

Project Summary

Feasibility: Tiritiri Matangi and Motuora Islands are predator-free islands in the Hauraki Gulf, and are administered by the New Zealand Department of Conservation (DOC). These islands have had a long history of human occupation and have suffered severe habitat degradation through burning and livestock grazing. Currently, these islands are open to the public and are greatly supported by independent community restoration groups, Supporters of Tiritiri Matangi Inc. (SoTM) and Motuora Restoration Society (MRS). Both islands have large areas of established coastal vegetation, and are becoming progressively similar to the more pristine offshore islands that typically support a high density and diversity of reptile species. As part of each islands' restoration initiatives, re-introduction of native reptiles is important and *H. duvaucelii* were chosen for their ecological roles and charismatic appearance. Release sites within each island were selected on the basis of suitable habitat and food resources occurring in the immediate and surrounding areas. Korapuki Island, in the Coromandel, was selected as the source site for *H. duvaucelii*, as it supports a high density population of *H. duvaucelii*, and is therefore capable of sustaining the effects of harvesting. The island also represents the closest *H. duvaucelii* source population to the release islands. Consultation was done between DOC, local iwi tribes, SoTM, MRS and Massey University to determine research objectives, and logistics.

Implementation: Pre-translocation reptile surveys were conducted on Tiritiri Matangi and Motuora Islands to confirm local absence of *H. duvaucelii*, identify

Tiritiri Matangi Island (*left*) and Motuora Island (*right*) © A. Mitchell & MRS

other potential mutually exclusive/ competitive species, and to detect potential pathogens within the resident reptile population. Thirty-nine *H. duvaucelii* were captured from Korapuki Island, with a 50:50 sex ratio and a preference for gravid individuals amongst the females. Geckos were quarantined for two weeks to test for *Salmonella*, *Cryptosporidia*, and *Giardia*, and to provide opportunity for expulsion of unwanted material (i.e. seeds) and organisms from their bodies. No animals tested positive for the selected pathogens and all animals were deemed acceptable for translocation. All geckos were implanted with PIT tags prior to release, to allow individual identification and therefore provide detailed re-capture histories to be built following translocation. Half of the animals (i.e. 10 geckos per island) were also fitted with two-stage, externally mounted, backpack transmitters to allow detailed tracking of movement, dispersal, and habitat-use. Morphological measurements were recorded before being transported to the islands, via boat, in individually housed plastic tubes. Nineteen and 20 *H. duvaucelii* were released onto Tiritiri Matangi and Motuora Islands, respectively, in December 2006.

Post-release monitoring: Geckos were monitored using a suite of standard techniques, including radio-telemetry, spotlight searches, footprint tracking tunnels, artificial refuges and funnel traps, to increase the detection probability of *H. duvaucelii*. Monitoring took place within a defined area surrounding each release site. Radio-telemetry data collected within the post-release year indicated that initial movements by *H. duvaucelii* were low but increased considerably over time as animals dispersed further away from release sites. *H. duvaucelii* utilised a range of habitat types at release sites. Annual monitoring since 2007 has revealed that dispersal movements have varied considerably among the adult founders. Additionally there were no post-release mortalities recorded and all re-captured individuals showed marked increases in body condition over the year-long intensive monitoring period. Island-born juveniles (offspring of released gravid founders) were recorded 12 months after the release and all juveniles were in excellent condition, suggesting their capability of securing resources on the islands was adequate. Recent monitoring in 2009 also showed the recruitment of a second offspring cohort, on Tiritiri Matangi Island, indicating the first occurrence of natural matings post-translocation. This information provides baseline references on habitat size and quality requirements, dispersal behaviour and expected reproduction by *H. duvaucelii* post-release, which can be used to select optimum release sites and maximise the success in future translocations. Long-term monitoring plans for *H. duvaucelii* will involve annual surveys, with methods designed by researchers and implemented by SoTM and MRS volunteers. Lead volunteers will be trained prior to undertaking these surveys by current herpetologist associated with the project. Annual monitoring will involve spotlight searches, footprint tracking tunnels, funnel traps, and artificial refuge techniques. These methods will provide an index of abundance and allow detection of juvenile geckos via footprint tracking tunnels. Information from these efforts will be sufficient to determine breeding success and population growth on the islands.

Major difficulties faced

- Detecting nocturnal, semi-arboreal species such as *H. duvaucelii* can be difficult when they exist at low densities. Despite employing a suite of different monitoring techniques, re-capture rates of *H. duvaucelii* were low. This was due to monitoring efforts that focused intensely within the release sites, and therefore any dispersal out of these sites by *H. duvaucelii* may not have been detected.
- The original founder population sizes were low and concerns regarding the long-term genetic viability of the populations are realized. The effects of inbreeding on these populations are speculative and genetic sampling over time is being conducted. Future population augmentation for long-term viability is a valid possibility.
- Community restoration group volunteers are very useful for collecting data however they are often insufficiently trained to undertake scientific monitoring. Since this project is focused on involving volunteers, it is a priority to provide training and support during the first few monitoring periods. This support will be required until such time that volunteers are capable of confidently locating, capturing, and processing the animals.
- Problems arose with respect to radio-transmitter harnesses causing skin abrasions to some *H. duvaucelii*. Affected individuals were treated and a softer, more flexible material was used for transmitter harnesses thereafter, with no adverse effects.
- The high cost and limited funding for disease-screenings restricted the project in performing comprehensive testing of both translocated individuals and resident populations at release sites. Priorities for specific pathogens of concern and a smaller sample size from the resident populations had to be selected instead.

Major lessons learned

- Monitoring methods vary considerably in their detection rates and are influenced by both spatial and environmental conditions. When employing a suite of monitoring techniques, good positioning of each method based on species behavior (i.e. vertical and horizontal spacings, and habitat types) and ideal environmental conditions (i.e. warm, calm, moonless nights in summer) needs to be considered to maximize the efficacy in detecting *H. duvaucelii*.
- The large variation in post-release movements and habitat-use by *H. duvaucelii* in this study can be used as guidelines for conservation managers

in selecting future release sites that will fulfill the habitat and size requirements of the species.

- Long-term monitoring is essential in long-lived species, for determining their translocation success and assessing the populations' genetic viability.
- Community restoration groups and NGOs have great interest in conservation and are valuable contributors as data collectors. Their involvement should be incorporated into scientific-based translocation programs.
- Utilizing SoTM and MRS volunteers as part of a researcher's monitoring group proved to be beneficial and valuable for both parties. Not only could volunteers learn and gain skills, but they were also important for advocating reptile conservation to the public and other community groups.
- It is important to have constant communication between DOC, community restoration groups, iwi tribes, and researchers. Good communication is needed to maintain relationships, share local knowledge and aid in funding for research and monitoring.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
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Reason(s) for success/failure:

- High number of individual founders re-captured on both islands (≥70%) within three months of release.
- Island-born juveniles with high body condition scores were captured on both islands one year post-release.
- Evidence of natural breeding occurring with a second generation of offspring detected three years post-release.
- Detailed information collected on the movements, dispersal, and habitat-use of *H. duvaucelii* post-translocation.
- Successful creation of at least one additional population of *H. duvaucelii* within their geographical range.

References

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