Recent developments in New Zealand herpetofauna research

Abstracts of papers presented at the 17th biennial conference of the Society for Research on Amphibians and Reptiles in New Zealand

J.M. Monks and S. Penniket

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CONTENTS

Recent developments in research on the herpetofauna of New Zealand

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J.M. Monks and S. Penniket (Compilers)

SRARNZ, Department of Conservation, PO Box 524, Moray Place, Dunedin 9058, New Zealand.
jmonks@doc.govt.nz

Abstract

Research on New Zealand's amphibians and reptiles is presented at the biennial conference of the Society for Research on Amphibians and Reptiles in New Zealand. This compilation includes abstracts from the conference held in 2017 at Whangarei Heads. The scope of the research presented ranges from species-specific studies to testing new techniques and, in most instances, includes application of the research to conservation.

Keywords: amphibians, reptiles, conference abstracts.

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1. Introduction

Reptiles and amphibians are important components of New Zealand ecosystems, but we are still trying to understand their diversity and know very little about their ecology. The Society for Research on Amphibians and Reptiles in New Zealand (SRARNZ) is made up of researchers, conservation practitioners and amateur herpetologists who are dedicated to understanding more about New Zealand's herpetofauna. Every two years, the Society holds a conference to bring people together to hear about the latest research and celebrate contributions targeted primarily at New Zealand frogs, lizards and tuatara.

In 2017, the 17th biennial conference of the Society was held at Whangarei Heads, Northland (Manaia Camp; 20–22 January). The conference included full-length presentations from 19 researchers and poster presentations from three researchers. Issues covered included translocation techniques, mitigation under the Resource Management Act 1996, monitoring programmes, citizen science, conservation management, invasion biology and climate change. Presentations also encompassed life history, morphology, colouration, ecophysiology and phylogeography of herpetofauna. Techniques were evaluated for measuring field body temperature in reptiles, inducing egg-laying and marking individuals. The keynote address examined the current state and future of New Zealand lizard research, and reflected on a recently published book that synthesises this information and can be used to direct future research (Chapple 2016).

Recently completed research projects in New Zealand herpetology that were reported on at the conference include understanding: (1) impacts of climate change on tuatara (Jarvie 2017; Jarvie et al. 2014), (2) indirect impacts of invasive predators on endemic frogs (Ramírez 2017; Ramírez et al. 2017), (3) colour variation and its role in avoiding predators (Baling 2017; Baling et al. 2016) and (4) invasion ecology of introduced rainbow skinks, *Lampropholis delicata* (Wairepo 2015), as well as improving success of green gecko translocations by using temporary pens to habituate animals to their environment (Knox et al. 2017; Knox & Monks 2014). Recent advances from a conservation management perspective include crisis management for a species at threat of imminent extinction (cobble skink; section 2.9), along with progress on understanding the biology and needs of other lizards considered critically endangered under the New Zealand Threat Classification System (section 2.10; Hitchmough et al. 2016).

A selection of the abstracts for talks and posters presented at the conferences is included here to allow wider use of the new knowledge and promote the value of the Society for understanding and conserving New Zealand's native herpetofauna. More detail on the research can be obtained by contacting the authors of each abstract directly or from full reports published elsewhere. Citations of published articles related to the talks presented are provided after the abstracts where relevant.

2. 2017 Conference abstracts

2.1 Camouflage in heterogeneous environments: an experimental test of the effect of prey colour and pattern complexity

Marleen Baling[1], Devi Stuart-Fox[2] and James Dale[1]

[1] Institute of Natural and Mathematical Sciences, Massey University (Albany Campus), Private Bag 102904, North Shore City, Auckland 0745, New Zealand.
m.baling@massey.ac.nz

[2] Zoology Department, University of Melbourne, Melbourne, Victoria 3010, Australia.

The cryptic colour patterns of prey populations inhabiting heterogeneous environments are expected to be strongly influenced by predator-driven selection. Visually-oriented predators may selectively attack prey based on their conspicuousness against different backgrounds, or via their frequency-dependent cognitive search images of prey (apostatic selection). Here, we tested two predictions that separate the two processes: avian predators are more likely to attack prey colour pattern variants that are mis-matched to their habitat background colour and complexity; and avian predators are more likely to attack the most commonly abundant variant in the population irrespective of their conspicuousness. A wild population of shore skinks (*Oligosoma smithi*) at a coastal sand dune site showed a non-random distribution of colour patterns that strongly corresponded to a vegetation gradient. This suggests the function of prey colouration for background-matching. However, prey models in our field experiment representing the more common variants were attacked most frequently, irrespective of background-matching. This study shows evidence that both selective processes are present in the population, but that apostatic selection is a stronger influence in maintaining colour pattern variation.

2.2 A long-term look at Maud Island frogs (*Leiopelma pakeka*)

Ben D. Bell[1], Elizabeth A. Bell[2] and Shirley A. Pledger[3]

[1] School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand.
ben.bell@vuw.ac.nz

[2] Wildlife Management International Ltd., PO Box 607, Blenheim, New Zealand.

[3] School of Mathematics and Statistics, Victoria University of Wellington, Wellington, New Zealand.

We report the latest findings from 40 years of demographic study of *Leiopelma pakeka* on Maud Island, Marlborough Sounds. In a 16 ha forest remnant where frogs had survived, two capture-recapture study plots have been operated since 1976, while over the entire remnant, full counts of frogs were made in 1993 and 2016. Further, an intra-island translocation to Boat Bay was carried out in 1984–85. These studies include some of the lengthiest population research on wild anurans to date, providing conservation-relevant data on population trends, distribution, spatial behaviour, survival rate, longevity and recruitment that reveal K-selected life-history traits in *L. pakeka*. Recent frog declines occurred on the two main study plots, but the population translocated to Boat Bay has increased, as did frog numbers counted over 16 ha between 1993 and 2016. We recorded high site fidelity and remarkable longevity in *L. pakeka* (>43 years). Possible factors influencing these demographic trends are reviewed, including weather, a mouse incursion and removal of over 1000 frogs from the island, mostly for conservation translocation.

2.3 Amphibian co-research project between Huanui College and University of Otago Frog Group

Javiera Cisternas[1,2], Luke J Easton[1], Christina Bone[3], Tyla Bowering[3], Jessica Macmenigall[3], Jameela McLean-Saad[3], Matariki Moetara[3], Emma Sanders[3], Zac Snushall[3], Stephen Towey[3], Nancy Longnecker[2] and Phillip J. Bishop[1]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand. cisja962@student.otago.ac.nz

[2] Centre for Science Communication, University of Otago, Dunedin, New Zealand.

[3] Huanui College, Whangarei, New Zealand.

The University of Otago Frog Group developed a co-research project with Huanui College, a secondary school located in Whangarei, Northland region. The aim of this work was to characterise microhabitat features of a *Leiopelma hochstetteri* population, as well as to disseminate native frog conservation awareness amongst the participants. To characterise microhabitat features, we searched for frogs in a section of a stream located on Department of Conservation (DOC) land, accompanied by a DOC staff member (Tony Beauchamp). To ensure that volunteers collected high-quality information, they attended a two-day theoretical-practical workshop in which all the field topics were covered. Students were always accompanied by a frog expert (i.e. university student/staff, DOC personnel) in the field. Each frog that we found was used as the centre of a 1 m^2 quadrat, subdivided into 100 10 cm × 10 cm squares. These squares were classified according to their dominant coverage feature (e.g. vegetation, sand, gravel, cobble, boulder, leaf litter, woody debris, log). For every frog found, three additional quadrats were allocated and measured in nearby areas. No microhabitat differences were found between quadrats with frogs (N = 6) and quadrats without frogs (N = 13). Although more replicates are needed, our analyses validated the use of these data for management purposes, as these results follow similar patterns reported for other wild populations of this species. This project exemplifies the feasibility of generating useful natural-history information for frog management while empowering participants as ambassadors of amphibian conservation through their experience of being scientists for a day.

2.4 Review of translocation monitoring for *Leiopelma archeyi* in Pukeokahu Forest

Javiera Cisternas[1], Jennifer M. Germano[2], Luke J. Easton[1], Abi Quinnell[2], Tertia Thurley[2] and Phillip J. Bishop[1]
cisja962@student.otago.ac.nz

[1] Department of Zoology, University of Otago, Dunedin, New Zealand.

[2] Department of Conservation, New Zealand.

In 2006, 70 individual frogs from Whareorino Forest were translocated to Pukeokahu, Pureora Forest, as part of an emergency response to secure a new population of *Leiopelma archeyi* from declines caused by chytrid fungus (*Batrachochytrium dendrobatidis*). Our aims were to 1) determine whether monitoring of the Pukeokahu population addressed the objectives of this translocation, and 2) provide recommendations for future monitoring. Translocation objectives need to be quantifiable and measurable. The original objectives included '[to] establish a new wild population for this species' and '[to obtain] high (long-term) survival rate [of the population].' While these are worthwile and aspirational, they lacked the ability to guide adaptive management. We therefore recommend that these objectives incorporate specific details such as the target number of individuals, actual quantities for rates (i.e. what is 'high'?), and the timeline by which these conservation goals should be reached. In addition, we question the Jolly-Seber open population model assumption of equal capture probability for individuals. We found that the snout-to-vent length of frogs captured during the breeding season (i.e. when the male is guarding eggs) was significantly larger (27.9 ± 7.3 mm; mean ± SE) than for frogs captured in non-breeding seasons (24.6 ± 8.9 mm), which implies a bias of females monitored during the former period. Such findings support the necessity to regularly include monitoring data into monitoring protocols and to review progress of conservation programmes to ensure that resources are spent wisely to reach intended goals, and so that management can be adapted if required.

2.5 Field body temperatures of New Zealand lizards: patterns to date and recommendations for future data collection

Alison Cree[1] and Kelly M. Hare[2]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand. alison.cree@otago.ac.nz

[2] School of Graduate Research, University of Waikato, Hamilton, New Zealand.

Field body temperatures (FBTs), especially those attained by day when solar radiation is available, have a crucial influence on the physiological performance of lizards. Worldwide, different lineages of lizards have evolved differences in FBTs but we lack a good understanding of patterns in New Zealand lineages. Impending climate change has accentuated the importance of knowing the range of body temperatures that each species tolerates in the wild. For a chapter in the recent book on New Zealand lizards, we reviewed information available on daytime FBTs (spot measurements) during spring and summer for 13 species. The data are limited by sample sizes that are often small, by a frequent lack of control for ambient air temperature and by an absence of data for nocturnal skinks. However, it is apparent that (i) mean daytime FBTs in New Zealand lizards (range 17–25°C) are generally low compared with lizards overseas, including those from similar latitudes; (ii) mean daytime FBTs are broadly similar for diurnal geckos, diurnal skinks and nocturnally foraging geckos that cryptically bask; (iii) mean daytime FBTs are sometimes warmer in pregnant females than males; and (iv) no individuals have exhibited daytime FBTs exceeding 34°C. Given the minimal implications for researcher time and animal welfare (especially with the recent advent of non-contact infrared thermometers), we encourage field researchers to collect and report FBTs of lizards more frequently, and we make recommendations for how best to do so. These data will contribute to informed decisions in conservation management that relate to thermal tolerance limits.

2.6 Pilot study to determine the safety and migration patterns of PIT tags (Iso Midichip) in the coelomic cavity of the rainbow skink (*Lampropholis delicata*)

Sabina Darke[1], Jodi R Salinsky[2] and John K Perrott[3]

[1] Environmental and Animal Sciences, Unitec, Institute of Technology, Auckland, New Zealand. sdarke@unitec.ac.nz

[2] Auckland University, Auckland, New Zealand.

[3] Institute of Applied Ecology, Auckland University of Technology, Auckland, New Zealand.

The use of internally implanted Passive Integrated Transponder (PIT) tags enables researchers to track and identify individual animals over extended periods of time. Increasingly, smaller PIT tags are becoming available, which raises the question of how small an animal this technology can feasibly be used in. In this pilot study we anaesthetised five rainbow skinks (*Lampropholis delicata*) ranging from 2.6 to 4.3 cm snout-vent length (SVL) using a diluted Metomidine/

Ketamine mixture. After the skinks were at a surgical plane of anaesthesia, we implanted the 8 mm × 1.4 mm microchips into the coelomic cavity. After five minutes the animals were euthanised by decapitation and dissected to observe the trauma caused by the PIT tag insertion.

Three of the animals had a puncture wound at the insertion site but no obvious internal damage. One skink (3.8 cm SVL) had a puncture wound at the insertion site and free blood in the coelomic cavity. The insertion mechanism of the PIT tag was not smooth and a sudden dislodgement of the piston caused an uncontrolled movement during the insertion of one of the PIT tags. This caused the injury leading to free blood in the abdominal cavity. The smallest skink (2.6 cm SVL) needed two injections of the anaesthetic drug and died of a presumed drug overdose, before the PIT tag was inserted. Following these findings, we will microchip an additional 10 skinks, no smaller than 3.8 cm, to observe the safety and migration pattern of the PIT tags during a four-week duration.

2.7 Re-examining Leiopelmatidae inside out: skeletal and external morphology of New Zealand's endemic frogs suggests extinctions of cryptic taxa

Luke Easton[1], Amanda Haigh[2], Ben Bell[3] and Phil Bishop[1]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand. easlu938@student.otago.ac.nz

[2] Department of Conservation, New Zealand.

[3] School of Biological Sciences, Victoria University, Wellington, New Zealand.

The taxonomic status of New Zealand's endemic and threatened leiopelmatid frogs has been debated for many years. Clarifying these uncertainties is thus integral for their conservation, especially given the risk of extinctions of cryptic taxa. We addressed this concern by re-examining the skeletal and external morphology of extinct and extant *Leiopelma* spp. to determine morphological differentiation between and within certain taxa. To do this, we recorded limb element sizes and maxillae shape from subfossil and modern material held at New Zealand museums. Size measurements were taken using Vernier callipers, whereas maxillae shape was recorded by photographing specimens and selecting coordinates of osteological features on downloaded images. External morphological data of live *L. hochstetteri* were provided by the Department of Conservation. Our results suggest that extinct taxa are morphologically more distinct than extant taxa. Sizes generally overlapped in extant taxa, but maxillae shape provided several distinguishing features, such as the level of ossification present in the osteologically similar *L. archeyi* and *L. pakeka*. Phenotypic differentiation within contemporary *L. hochstetteri* populations was low overall, although morphological distinctiveness for some taxa supports their classification as evolutionarily significant units. Furthermore, geographical variation in subfossil sizes of widespread taxa indicate possible extinctions of cryptic taxa prior to and/or shortly after human arrival. Future research will require a genetic approach that utilises modern and ancient DNA from subfossils. That way, the taxonomic diversity of the genus *Leiopelma* can be viewed in more detail, rather than just using morphology, and from both contemporary and historical perspectives.

2.8 Developing better methods to induce egg laying in turtles

Mark Feldman and Elizabeth Feldman

PO Box 285, Kerikeri, New Zealand.
nz.feldman@yahoo.com

Oxytocin has been used for decades to induce turtles to lay their eggs. Unfortunately, it often leads to partial clutches or fails to work at all. It also has some serious side effects.

For the past 28 years we have experimented with 21 different agents in order to develop more effective induction agents than oxytocin. Over 2600 red-eared sliders (*Trachemys scripta elegans*) and varieties of map turtles (*Graptemys*), nearly 900 spiny softshells (*Trionyx spiniferus*) and over two hundred individuals of other species have been induced. Side effects and long-term sequelae were evaluated by close follow-up of a colony of 10 red-eared slider females maintained in New Zealand. There has been no mortality though there were frequent induction failures, false nesting, and delayed ovulation observed when we utilised oxytocin as the only agent. Once we stopped using oxytocin the side effects abated.

For slider turtles and a wide variety of map turtles a 94% success rate was achieved by using 1.5 mg/kg prostaglandin F2 alpha (Lutalyse) alone. Giving the injections just after dark and leaving the animal undisturbed in the dark after treatment improves the outcome. For slider turtles and map turtles that failed to lay any or all eggs after getting 1.5 mg/kg Lutalyse it is best to wait 5-6 hours and then treat with 0.5 mg/kg romifidine (Sedivet) followed immediately by 1.5 mg/kg Lutalyse. For spiny soft shell turtles an 80% success rate was achieved by treatment with 0.5 mg/kg romifidine followed by 1.5 mg/kg Lutalyse 20 minutes later.

2.9 Managing an extinction crisis for a recently discovered skink

Rod Hitchmough[1], Lynn Adams[1], Tony Jewell[2] and Scott Freeman[3]

[1] Department of Conservation National Office, PO Box 10420, Wellington 6143, New Zealand. rhitchmough@doc.govt.nz

[2] 35 Brown Street, Invercargill, New Zealand.

[3] Department of Conservation Westport Office, PO Box 357, Westport 7866, New Zealand.

Cobble skinks were discovered in 2007 by Tony Jewell, and illustrated in his field guide (Jewell, 2008, 2011). They are known only from Granity, north of Westport, where they are sympatric with more typical speckled skinks. They are distinguished largely by their smaller size (c. 65 mm v. c. 80 mm snout-vent length, c. 5 g v. c. 10 g in weight). When discovered, they were very localised in distribution, but extremely abundant. Genotyping of small samples associated Greaves et al.'s (2008) clade 2a of the *Oligosoma infrapunctatum* complex with the cobble skinks. In early 2016 Tony Jewell was contracted to do a follow-up survey to more comprehensively assess the cobble skinks' status and distribution, hoping that other populations could be discovered. Instead, he found no other populations during a comprehensive survey of the coastline from Cape Foulwind to Gentle Annie Point. At Granity, loss of habitat to coastal erosion was continuing rapidly, most habitat was already gone, and the cobble skink was on the verge of extinction. An emergency salvage into captivity was undertaken. Twenty-seven salvaged cobble skinks are now held at Auckland Zoo, and four have subsequently been born in captivity. Preliminary genetic results indicate a complex evolutionary history involving historical hybridisation among four deeply divergent mitochondrial lineages, but the skinks in captivity are from a single nuclear gene pool and are readily distinguishable from sympatric speckled skinks by several morphological characters. They are about half the body mass of speckled skinks at all ages. Options for future recovery will be discussed.

2.10 Progress towards understanding the biology and conservation requirements of the Chesterfield skink

Rod Hitchmough, Lynn Adams and Les Moran

Department of Conservation National Office, PO Box 10420, Wellington 6143, New Zealand. rhitchmough@doc.govt.nz

At the last biennial SRARNZ conference we reported some very preliminary observations on this species. Since then we have photo-identified c. 120 animals and had a good re-sight rate which allowed us to document their habitat use, movements, reproduction and growth. We believe the total population to be less than 200, and the adult population to be about 40. They are still known only from the original site, <1 ha in area. Chesterfield skinks are confined to a single narrow strip of rank pasture grass between grazed farmland and active dunes with marram-dominated vegetation. Other sightings have been followed up and nearly all confirmed to be different species. This includes a locality only 3 km down the road where a different, equally poorly known, species in the *Oligosoma infrapunctatum* complex has been found.

2.11 Identifying climatically suitable habitat for tuatara: a mechanistic approach to species distribution models

Scott Jarvie[1], Philip J. Seddon[1], Alison Cree[1] and Michael R. Kearney[2]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand. sjarvie@gmail.com

[2] School of BioSciences, The University of Melbourne, Parkville, Victoria, Australia.

A major challenge facing conservation managers seeking to restore populations of threatened endemic species is the identification of suitable translocation sites under current and future climates. Mechanistic species distribution models (SDMs) hold considerable promise in identifying future conservation translocation sites. These SDMs typically link taxon-specific parameters on behaviour, morphology and physiology with climate variables to generate spatially resolved predictions of microhabitats that are habitable. Here we illustrate this approach using the example of a rare endemic reptile from New Zealand, the tuatara, *Sphenodon punctatus*. The *Sphenodon* genus was once widespread on the two main islands of New Zealand and many offshore islands, but now tuatara naturally inhabit only 32 islands following the arrival of humans and introduced mammalian predators. A long-term recovery goal for tuatara is to restore populations. When the mechanistic SDM was parameterised with tuatara-specific data and driven by historical daily weather data from New Zealand's Virtual Climate Station Network, predictions of seasonal activity patterns for free-roaming tuatara matched empirical observations from three locations (Te Hauturu-o-toi / Little Barrier Island, Stephens Island (Takapourewa) and Ōrokonui Ecosanctuary). For future climates the mechanistic SDM predicted an increase in activity period, metabolic costs and rate of water loss at all locations. Through these comparisons insight is gained into the ecological and physiological factors that will constrain tuatara distribution at future translocation sites. Finally, we discuss how the predictions can be integrated with energy budget models that can capture the consequences of biophysical constraints on growth, reproduction and body condition.

2.12 What mainland regions of New Zealand will be climatically suitable for tuatara under climate change?

Scott Jarvie[1], Trevor H. Worthy[2], Paul Scofield[3], Philip J. Seddon[1] and Alison Cree[1]

[1] Department of Zoology, University of Otago, Dunedin 9054, New Zealand. sjarvie@gmail.com

[2] School of Biological Sciences, Flinders University, South Australia 5001, Australia.

[3] Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand.

A key component in planning conservation translocations is the identification of release sites that match the biotic and abiotic needs of a focal species under current and future climates. Correlative species distribution models (SDMs) have been used to identify potential future habitat for species. However, correlative SDMs have rarely used past locations of a species to identify climatically suitable habitat for translocations. Here we apply three correlative SDMs to identify climatically suitable habitat for an iconic reptile from New Zealand, the tuatara *Sphenodon* sp., under current and future climates. The *Sphenodon* genus was once widespread on the two main islands of New Zealand and many offshore islands, but *S. punctatus* now naturally inhabits only 32 islands following the arrival of humans and introduced mammalian predators c. AD 1280. We fitted correlative SDMs with annual means and seasonal extremes of climate data, relative to data on distribution of tuatara from remnant populations and from past locations (fossil deposits of Holocene age, and known or probable extinctions from offshore islands). For current climate, predictions from the three correlative SDMs were similar. Under future climates, we found discrepancies between the correlative SDM projections, with more uncertainty between the modelling methods than between climate scenarios. Despite discrepancies, the three correlative SDMs projected an increase in area of climatically suitable habitat for *Sphenodon* sp. under future climates. This correlative approach to modelling habitat using data from past distribution can be seen as a model system for the management of refugee species threatened by climate change.

2.13 Soft-release, but not cool winter temperatures, reduces post-translocation dispersal of jewelled geckos

Carey D. Knox[1], Scott Jarvie[2], Luke Easton[2] and Joanne M. Monks[3]

[1] Knox Ecology, Dunedin, New Zealand. knox.ecology@gmail.com

[2] Department of Zoology, University of Otago, Dunedin, New Zealand.

[3] Department of Conservation, Dunedin, New Zealand.

Translocations are an important conservation tool, but many are unsuccessful. Soft-release translocations involve holding animals on site for a period prior to release, whereas hard-release translocations involve immediate release of animals into a new environment. Evaluating the relative impacts of hard and soft release on site fidelity of released individuals can be informative, especially when comparing between translocated and resident animals. We monitored the movement, dispersal and home range of both translocated (hard and soft-released) and resident jewelled geckos (*Naultinus gemmeus*) for three weeks during winter using radio telemetry. We also monitored a hard-released group during summer and incorporated data from a previously published soft- v. hard-release translocation of jewelled geckos undertaken in spring. In winter, soft-released geckos dispersed less than hard-released geckos and both soft-released and resident geckos had significantly smaller home ranges than those hard-released. Further, area occupied by soft-released geckos remained constant during the tracking period, but increased 20-fold for

hard-released geckos. Mean dispersal distances were not influenced by season or the amount of time in an enclosure prior to soft-release (i.e. 4 months yielded similar results to 9 months). Translocations employing a soft-release strategy may have value for a wide range of lizard species and could contribute to translocation success.

Full article: Knox, C.D.; Jarvie, S.; Easton, L.J.; Monks, J.M. 2017: Soft-release, but not cool winter temperatures, reduces post-translocation dispersal of jewelled geckos. *Journal of Herpetology 51(4)*: 490–496.

2.14 Monitoring gecko populations at Auckland Council Regional Parks

Sabine Melzer[1], Darryl MacKenzie[2], Trent Bell[3], Sarah Herbert[3], Dylan van Winkel[4], Chris Wedding[4], Miranda Bennett[1], Melinda Rixon[1] and Su Sinclair[1]

[1] Biodiversity team, Auckland Council, Auckland, New Zealand. sabine.melzer@gmail.com

[2] Proteus Wildlife Research Consultants, Dunedin, New Zealand.

[3] EcoGecko Consultants, Wellington, New Zealand.

[4] Bioresearches Group Ltd, Auckland, New Zealand.

In 2011 Auckland Council implemented a long-term, standardised monitoring programme to gain a better understanding of gecko populations at Shakespear, Tāwharanui, Waitakere and Whakanewha Regional Parks. The two survey approaches used were transects of 40 closed-cell foam retreats (CFR) and visual encounter surveys at night (VES). CFR data was analysed using the multi-scale occupancy model of Nichols et al. (2008) and mark-recapture estimates of abundance calculated using the Huggins estimator (Huggins 1991). VES data were analysed using regular occupancy models (MacKenzie et al. 2002). Up to three factors were considered for transect and CFR-level occupancy: park, park proximity (as an indicator for pest management) and year. *Dactylocnemis pacificus*, *Naultinus elegans* and *Mokopirirakau granulatus* were caught but detection varied between parks and with survey method. CFR and transect-level occupancy of *M. granulatus* is lower outside of Whakanewha and geckos have smaller snout-to-vent lengths than inside the park. Model-averaged estimates for transect-level occupancy from VES surveys were highest at Tawharanui and Whakanewha for *M. granulatus* (>0.9) and *N. elegans* (>0.8) and overall low for *D. pacificus* (<0.3). Model-averaged estimates for detection probabilities for all species were higher for VES surveys and increased with person-hours searched compared with CFR surveys. VES surveys consistently detected more species at any given park than CFR surveys. Mark-recapture estimates of abundance have wide confidence levels due to the low number of recaptures. Changes to the monitoring design can be implemented to increase understanding of the effective area surveyed and reduce uncertainty for occupancy estimates.

2.15 Indirect effects of an alien predator on a population of the native frog *Leiopelma archeyi*

Patricia A. Ramírez, Ben D. Bell and Nicola J. Nelson

School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand. patty.a.ramirezs@gmail.com

Introduced predators have been linked to various amphibian population declines and extinctions. Besides predation, introduced predators can have indirect impacts on native populations that alter the prey's ecology, imposing changes on its behaviour, such as microhabitat use. *Leiopelma archeyi* is a terrestrial and nocturnal species that is found within the Coromandel Peninsula and Whareorino Forest, where it coexists with introduced predators like rats. After evidence of rat predation, a rat control programme (ground-based bait stations) was established on half of the frog's distribution range in Whareorino Forest. A frog monitoring programme was set up to detect changes in the population structure. However, the indirect impacts these predators may have on *L. archeyi* have not been investigated. We assessed whether introduced predators impose indirect effects on frogs by modifying their microhabitat use and home range. For this, we used DOC's frog capture data (2005–13) from areas with and without rat control and analysed the microhabitat where frogs were found as well as their home range. Rat control did not influence home range of frogs, but it affected their use of microhabitat. In the rat control area frogs used a higher proportion of soil and leaf litter and were more likely to be at ground level. Results suggest that rats may be imposing indirect effects on *L. archeyi* by modifying their microhabitat use. Indirect effects of predation should be incorporated in the management of species as they can affect growth and survival of individuals and, ultimately, population viability.

2.16 The development of an effective detection technique: delimiting a population range of the plague skink (*Lampropholis delicata*)

Jacqui Wairepo[1], Dianne Brunton[1], Nick Waipara[2] and James Reardon[3]

[1] Institute of Natural and Mathematical Sciences, Massey University, Auckland, New Zealand. Jacqui.wairepo@wildlands.co.nz

[2] Auckland Council Biosecurity, Auckland, New Zealand.

[3] Department of Conservation, Te Anau, New Zealand.

Invasive alien species pose an increasing and ongoing threat to global indigenous ecosystems and economies. When border security systems fail to prevent the arrival of a novel invader, effective early detection systems may prevent its establishment. Unknown detection probabilities, imperfect detection techniques and lag phase population growth traits render early detection a challenging task for biosecurity managers who are tasked with forming scientific conclusions and management decisions on limited resources. The invasive plague skink (*Lampropholis delicata*) was detected in April 2013 at Tryphena Wharf on Great Barrier Island. Due to a lack of effective rapid response detection tools, the true population range remained unclear for the following 18 months. An intensive network of invertebrate sticky traps was installed to create a surveillance boundary line encompassing c. 5.15 ha to determine if the population had dispersed beyond this area. In order to make inferences about the power of the surveillance system, detection probabilities were quantified, along with a retrospective power analysis to assess the optimum number of surveys, survey sites and likelihood of falsely declaring species absence. No plague skinks were detected at or beyond the boundary line. Power analysis results indicated that the implemented effort was sufficient to detect skink populations with detection probabilities between 0.2 and 0.3 with 95–99% confidence, with the likelihood of declaring a false absence calculated at $p = 0.05$. Invertebrate sticky traps have proven to be an effective tool for the detection of plague skinks in low densities, when installed in a systematic but targeted system.

2.18 Split NZ: phylogeographic breaks in the South Island fauna and their causes

Graham Wallis

Department of Zoology, University of Otago, Dunedin, New Zealand.
g.wallis@otago.ac.nz

The beech gap of the South Island was first documented in 1926 and subsequently generalised to several groups. The general pattern is one of low diversity/endemism in the central (Canterbury) region, separating regions of high diversity to the north and south. Suggested causes of this pattern were glaciation (recent), tectonic rifting (ancient), or some intermediate combination of tectonics and sea-level change. A recent review using 13 genera of alpine/montane birds and insects shows a repeated phylogeographic split between northern and southern forms about 2 million years ago, centred on what was a narrow glacial alpine neck in the early Pleistocene. South Island alpine taxa seem to have preserved a vicariant genetic break from the first of many glaciations, in many cases resulting in speciation. There are geological, climatic and population genetic reasons for this structure. Most of the published phylogenies of geckos and skinks involve taxa whose most recent common ancestors precede the time frame above. *Hoplodactylus* "Southern Alps" v. *H.* "Otago/Southland", and *H. kahutarae* + *H. granulatus* v. a clade of seven southern taxa, both fit geographically, but are likely too old. The same goes for skinks. Even an intraspecific analysis of *Oligosoma nigriplantare polychroma* yields a split that is over two-fold too large to be attributable to Pleistocene glaciation. Unless the molecular clocks used for geckos and skinks are too slow, more intraspecific studies are required to see whether glaciation has left a N–S trace in the herpetofauna.

2.19 Urban RMA lizard mitigation case studies and the importance of post-management monitoring

Chris Wedding

Bioresearches Group Limited, Auckland, New Zealand.
chris.wedding@bioresearches.co.nz

Our understanding of native lizard distribution and habitat values has improved markedly over the last decade, particularly in the Auckland region. Lizard survey and management as a requirement under the Resource Management Act (1991) has contributed substantially to this information in the Auckland region where lizard-related consent conditions have become standardised by the Auckland Council. However, rapid population growth and urban sprawl are driving pressure on wildlife habitats, including those of native lizards. At least five species of native lizard may be encountered within Auckland's urban boundaries (excluding Hauraki Gulf Islands) and all but one of these are classified nationally 'At Risk' by the Department of Conservation. Successful management of native lizard populations and their habitats requires effective methods to identify, capture and relocate significant species and populations, and to minimise, offset, or enhance habitat quality. I review some of Bioresearches' lizard management projects, discuss their outcomes and highlight opportunities for safeguarding indigenous lizard communities in the Auckland region for the future.

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