2023

DOC RESEARCH AND DEVELOPMENT SERIES 369

Recent developments in research on the herpetofauna of Aotearoa New Zealand

Abstracts of papers presented at the 18th biennial conference of the Society for Research on Amphibians and Reptiles in New Zealand

Deborah J. Wilson and Joanne M. Monks (Compilers)

Department of Conservation
Te Papa Atawhai

Te Kāwanatanga o Aotearoa
New Zealand Government

DOC Research & Development Series is a published record of scientific research carried out, or advice given, by Department of Conservation (DOC) staff or external contractors funded by DOC. It comprises reports and short communications that are peer reviewed.

This publication is available for download from the DOC website. Refer www.doc.govt.nz under *Publications*.

ISSN 1177-9306 (web PDF)
ISBN 978-1-7385800-0-2 (web PDF)

This report was prepared for publication by Te Rōpū Ratonga Auaha, Te Papa Atawhai / Creative Services, Department of Conservation; editing by Lynette Clelland and layout by Darcy Woods. Publication was approved by Hilary Aikman (Director, Terrestrial Biodiversity), Department of Conservation, Wellington, New Zealand.

Published by Department of Conservation Te Papa Atawhai, PO Box 10420, Wellington 6143, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing.

CONTENTS

Recent developments in research on the herpetofauna of Aotearoa New Zealand

Abstracts of papers presented at the 18th biennial conference of the Society for Research on Amphibians and Reptiles in New Zealand

Deborah J. Wilson[1,2] and Joanne M. Monks[1,3] (Compilers)

[1] Society for Research on Amphibians and Reptiles in New Zealand

[2] Manaaki Whenua – Landcare Research, Private Bag 1930, Dunedin 9054, New Zealand
wilsond@landcareresearch.co.nz

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

Abstract

Research on Aotearoa New Zealand's amphibians and reptiles was presented at the 18th conference of the Society for Research on Amphibians and Reptiles in New Zealand (SRARNZ). This compilation includes abstracts from the conference held online in February 2021. The scope of the research presented ranges from species-specific studies to ecological and evolutionary questions and application of new techniques. In most instances it includes application of the research to conservation.

Keywords: amphibians, reptiles, conference abstracts, SRARNZ

Wilson, D.J.; Monks, J.M. 2023: Recent developments in research on the herpetofauna of Aotearoa New Zealand. Abstracts of papers presented at the 18th biennial conference of the society for Research on Amphibians and Reptiles in New Zealand. *DOC Research and Development Series 369.* Department of Conservation, Wellington. 19 p.

1. Introduction

Aotearoa New Zealand is home to a diverse range of herpetofauna (tuatara, lizards, frogs, snakes and turtles). Despite significant biological knowledge of some aspects of the herpetofauna, many components are still very poorly known. The Society for Research on Amphibians and Reptiles in New Zealand (SRARNZ) is a group of researchers, conservation practitioners and amateur herpetologists who are dedicated to the pursuit of knowledge about Aotearoa New Zealand's herpetofauna.

The Society regularly holds conferences to share the latest research and celebrate contributions targeted primarily at frogs, lizards and tuatara in Aotearoa New Zealand.In 2021, the 18th biennial conference of the Society was held as the society's first virtual conference (18–21 February). The conference included five invited talks, 18 full-length presentations and 14 mini-oral presentations. Although most focus was on the herpetofauna of Aotearoa New Zealand, research on Australian frogs and lizards of the Lord Howe Island and Norfolk Island groups was also presented. The invited talks addressed: (1) predator-prey interactions in the context of restoration of lizards in Aotearoa New Zealand, (2) social interactions of lizards, (3) citizen science as a powerful tool in amphibian conservation (Rowley et al. 2020), (4) the role of indigenous languages in Aotearoa New Zealand (te reo Māori and ta re Moriori) in taxonomy (Veale et al. 2019) and (5) improving the conservation outcomes of mitigation translocations associated with human development.

Other work presented included regional biodiversity planning as well as taxon-specific research. Issues covered for frogs included behaviour, disease ecology, citizen science and methods for estimating abundance and occupancy. Lizard research included ecophysiology, biogeography, behaviour (including lizard 'personality'), translocation success, responses to mammal eradication, and reconstructing phylogeny using ancient DNA (Scarsbrook et al. 2021). Tuatara research presented focused on reproductive biology and behavioural ecology. For the first time there was a strong focus on alpine taxa, including basic biological knowledge of newly discovered alpine taxa (e.g. hura te ao gecko, *Mokopirirakau galaxias* (Knox et al. 2021)), emergence patterns of skinks, and evidence of predation on alpine lizards.

A selection of the abstracts for talks 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 Aotearoa 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.

2. 2021 Conference abstracts

2.1 Flexible mark-recapture methods for estimating abundance of Aotearoa New Zealand frogs

D. Armstrong[1], E. Hotham[1] and K. Muchna[2]

[1] Wildlife Ecology Group, Massey University, Private Bag 11222, Palmerston North, New Zealand. D.P.Armstrong@massey.ac.nz

[2] Boffa Miskell Ltd, Auckland, New Zealand

It is important for long-term conservation to have information on the abundances of species rather than just their distributions. However, estimating abundance is challenging for cryptic taxa like Aotearoa New Zealand's frogs and particularly challenging for Archey's frogs in the Coromandel Peninsula, where the species appears to be widely distributed but few data are available except for one small site. Estimating abundance requires information on detection probability which can be obtained using mark-recapture methods. However, traditional models usually require ≥5 surveys and good numbers of captures and recaptures at each site to obtain reliable estimates. These constraints make it difficult to estimate abundance over multiple sites while accounting for factors that may affect detection probability over time and space. We therefore developed a purpose-built closed-population mark-recapture model to estimate Archey's frog abundance over thirty-two $100m^2$ sites in the Coromandel Peninsula where each site was surveyed for just three nights. The model is coded in the Bayesian updating software OpenBUGS which fits models using MCMC (Markov-chain Monte Carlo) techniques, allowing flexibility to tailor the model to the circumstances at hand. For our scenario we combined a logistic detection function that incorporated effects of behaviour (i.e. reduction in detection after initial capture), temperature, humidity and random nightly variation, and a Poisson density function that incorporated effects of disturbance, elevation, vegetation metrics, and random spatial variation. The model performed well in terms of standard MCMC diagnostics, giving sensible estimates and 95% credible intervals for abundance at each site.

2.2 *Leiopelma* frog behaviour: what we know and what we need to know

B.D. Bell

Centre for Biodiversity and Restoration Ecology, Victoria University of Wellington, Wellington, New Zealand
ben.bell@vuw.ac.nz

The three evolutionarily distinct endemic leiopelmatid frogs of Aotearoa New Zealand illustrate both primitive (basal) and derived features. These are reflected in their terrestrial (*Leiopelma archeyi*, *L. hamiltoni*) and semi-terrestrial (*L. hochstetteri*) modes of life and, in turn, relate to their behaviour and ecology. Current knowledge of *Leiopelma* behaviour is reviewed, revealing many gaps in knowledge that require attention if conservation of these threatened species is to be enhanced. We know that behavioural aspects of habitat selection and water relations vary amongst species and relate to their life cycle stages, but we need to assess how the species might respond to climate change and, for mainland species, to the potential impacts of underground mining. We know that in their senses, modes of communication and anti-predator behaviours, differences and similarities occur between species and individuals, but we need to know more about their social behaviour, how individuals might vary, and how this variation relates to age

and sex. More research is also needed on olfactory communication and the part that calls play, if any, in social communication. The extent of knowledge of *Leiopelma* activity, movement and foraging behaviour, in part revealed by long-term monitoring of individuals over many decades, varies between species, but is especially limited for *L. hochstetteri*. Knowledge of juvenile dispersal behaviour, for example, is wanting in all species. What do these frogs do throughout the day and night, within refugia and when outside? Finally, we know much about *Leiopelma* breeding behaviour; but again, we need to know much more. Seeking knowledge about the behaviour of these distinctive frogs offers challenging opportunities for innovative research, assisted by the increased availability of new technologies.

2.3 Surface activity of diurnal skinks (*Oligosoma* spp.) in a remote alpine habitat

A. Bertoia[1], A. Cree[1] and J. Monks[1,2]

[1] Department of Zoology, University of Otago, Dunedin, Aotearoa New Zealand beraa464@ student.otago.ac.nz

[2] Department of Conservation, Dunedin, Aotearoa New Zealand

For lizards, daily activity periods are dictated by temperature and other weather variables, because lizards are heliothermic and rely on heat from their environment to promote physiological functions, including locomotion. In the alpine zone, periods that fall within lizards' preferred temperature ranges are limited due to prolonged winters and large daily temperature fluctuations. Understanding when periods of high lizard activity occur is integral for monitoring programmes and helps us understand how threats, such as introduced predators, may influence lizard populations. We used trail cameras to monitor the surface activity of diurnal skinks in the alpine zone (1150–1800 m a.s.l.) of western Otago to better understand the activity of heliothermic lizards in this habitat. Our study investigated (1) the influence of temperature and other weather variables on emergence and (2) the duration of surface activity when skinks do emerge. We recorded a wide range of temperatures from lizard models (constructed from copper) at basking locations (-5.4–57.0°C), while skink observations occurred when copper model temperatures were more restricted (12.8–51.0°C). Observations of skinks peaked when copper models were between 20–30°C, which follows trends observed in lower-elevation McCann's skinks and in cold-adapted skinks in Australia. When skinks were present on the ground surface, they were very mobile and only remained in the same position for 1–3 minutes at a time. Our study shows that alpine skink activity is dependent on sunny, moderate weather conditions, which occur infrequently during summer, and demonstrates the utility of trail cameras as an effective tool for monitoring lizard behaviour in a remote environment.

2.4 Do personality traits co-vary with baseline concentrations of glucocorticoids in a viviparous lizard?

A. Besson[1], S.L. Johnson[1], S. Nakagawa[2], S. Meylan[3] and A. Cree[1]

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

[2] Evolution & Ecology Research Centre and School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, Australia

[3] Sorbonne Université, iEES Paris, and CNRS-UMR 7618, Paris, France

Stable differences in physiology among individuals may facilitate the evolution of consistent individual differences in behaviour (i.e. animal personality). In particular, individual variation in hormonal response should be linked with exploration, aggression or risk-taking behaviours. Whereas this prediction is well supported for birds and laboratory-bred mammals, data on squamates (scaled reptiles) are currently lacking. We tested for covariation between basal glucocorticoid concentration (in faeces) and personality traits in a wild population of McCann's skinks (*Oligosoma maccanni*). We found that skinks showed consistent individual differences in behaviour; in particular, boldness, exploration and aggression were repeatable but not activity. We did succeed in developing a non-invasive method to measure glucocorticoid levels in *O. maccanni* which could be used in future research to look at physiological stress in lizards. We found that females had higher levels of glucocorticoids than males. Personality traits did not co-vary with baseline concentrations of glucocorticoids in *O. maccanni*, which is consistent with previous research carried out on other lizard species.

2.5 Origin and evolution of the lizard fauna of the Lord Howe Island – Norfolk Island region

R. Bray[1,2], M.B. Thompson[3] and D.G. Chapple[2]

[1] Tāmaki Paenga Hira Auckland War Memorial Museum, Auckland, New Zealand
rbray@aucklandmuseum.com

[2] School of Biological Sciences, Monash University, Melbourne, Australia

[3] School of Biological Sciences, University of Sydney, Sydney, Australia

Oceanic islands, particularly volcanic islands, have played a central role in the development and understanding of both biogeographic theory and the formation of species assemblages. Lord Howe Island (LHI) and Norfolk Island (NI) are located north of Aotearoa New Zealand. These island complexes are over 900 km apart and are the only remaining emergent portions of volcanic island chains that formed along the Lord Howe Rise and Norfolk Ridge approximately 6.4–6.9 and 2.3–3.0 million years ago, respectively. The islands exhibit flora and fauna that have consistent evolutionary relationships to the three biogeographic sources in the region.

The endemic reptile fauna of the Lord Howe Island and Norfolk Island groups comprise the Lord Howe Island gecko (*Christinus guentheri*) and the Lord Howe Island skink (*Oligosoma lichenigerum*). We used DNA sequence data (nuclear and mitochondrial DNA) in conjunction with a calibrated molecular clock to investigate the biogeographic origins of these species and to test hypotheses for the colonisation history of each species (relict lineage v. recent immigration) within the LHI-NI region.

Our research shows further evidence for a complex dispersal pattern in terrestrial reptiles within the Zealandia continental region, with evidence of multiple biogeographic origins and replicated evidence for long-distance overwater dispersal in both skinks and geckos. Molecular data support the hypothesis that demonstrates that the extant lizard fauna of Lord Howe Island and Norfolk Island are paleoendemics and remnants of relict lizard fauna in the region.

2.6 Life on the edge: a cold-adapted lizard active at near-freezing temperatures

C. Chukwuka[1], J. Monks[1,2] and A. Cree[1]

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

[2] Department of Conservation, Dunedin, New Zealand

Cold-adapted lizards live in environments where ambient air temperature is frequently less than preferred body temperature. Night-time air temperature is predicted to increase with global climate change. Whether this increase will be beneficial to cool-temperate lizards, by creating a thermal environment that enhances physiological processes, remains poorly known. In this study, we investigated the nocturnal emergence of a cold-adapted, viviparous gecko (*Woodworthia* "Otago/Southland") at Macraes in eastern Otago, to understand if warmer night-time temperature enhances activity. We measured the operative temperature (*T*e) available to geckos when emerged, using dataloggers inside lizard models, and concurrently assessed night-time emergence activity using time-lapse trail cameras, for 28 days in each of the four seasons. Also, we measured field body temperature (*T*b) of emerged geckos of different life-history groups at night using a thermal infrared camera, to understand how weather conditions and night-time rock surface temperature affect field *T*b. From the results, field *Te* (operative temperature), nocturnal emergence activity, and field *T*b (body temperature) increased with increasing night-time temperature. Nocturnal emergence was high in spring and summer, but low in autumn and winter. Geckos were active at a wide range of temperatures (1.4–22.63°C), with rock surface temperature typically higher than air temperature and field *T*b. Otago/Southland geckos are capable of activity at near-freezing temperatures of 1.4°C, suggesting that opportunities to emerge at night are likely to increase under future climate scenarios.

2.7 Bd detection on native frogs at select Aotearoa New Zealand sites: 20 years on

A. Eda[1], J. Stanton[2] and P. Bishop[1]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand
adria.eda@postgrad.otago.ac.nz

[2] Department of Anatomy, University of Otago, Dunedin, New Zealand

More than 20 years ago, a deadly chytrid fungus, *Batrachochytrium dendrobatidis (*hereafter Bd*),* was found on the skin tissues of an introduced frog species *Litoria raniformis* in Aotearoa New Zealand. Two years later, a dead *Leiopelma archeyi* was found in the Coromandel Region and confirmed to be infected with Bd. This was the first record of Bd presence on New Zealand native species. The threat of Bd resulted in translocation of frogs to Bd-free sites, with Bd-positive frogs sent to the University of Otago for further analysis. This project aimed to assess the status of Bd on native frog species in select sites in New Zealand. In this study, a TaqMan screening assay using the Bioline SensiFAST Probe kit was optimised to detect Bd. A total of 100 frogs from Whareorino Forest, University of Otago Animal Facility and Auckland Zoo were screened for Bd presence. Thirteen percent of the *Le. pakeka* and 3.17% of the *Le. archeyi* were Bd-positive, and all *Le. hochstetteri* were Bd-negative. Bd-positive frogs did not show any signs

of fungal infection. This finding confirmed that Bd persists on New Zealand native frogs two decades since its first discovery.

2.8 Evaluation of site-occupancy modelling as a technique to monitor Archey's frog (*Leiopelma archeyi*) populations at low densities

A. Haigh[1], P. Stewart[2], M. Stainbury[3], K. Brown[3] and W. Fan[4]

[1] Department of Conservation, Taupō, New Zealand
ahaigh@doc.govt.nz

[2] Red Admiral Ecology, Coromandel, New Zealand

[3] Department of Conservation, Thames, New Zealand

[4] Auckland University of Technology, Auckland, New Zealand

Archey's frog (*Leiopelma archeyi*) is the smallest living terrestrial native frog in Aotearoa New Zealand and is classified as At Risk–Declining under the New Zealand Threat classification system. It is known from two locations, Coromandel Peninsula and Whareorino Forest. Frogs have also been translocated to Pureora Forest. These locations are in the northern North Island.

Populations on the Coromandel Peninsula suffered a severe (88%) decline 20+ years ago and to date we have no evidence of recovery. In 2008, to better understand population status and trends, two capture-recapture monitoring plots were established on the Coromandel Peninsula. However, both plots were abandoned in 2011 due to insufficient frog recaptures. Consequently, an alternative method to capture-recapture which can be applied to low density Archey's frog populations and accounts for detection probability, is needed.

We evaluated site occupancy modelling as an alternative method for an Archey's frog monitoring programme. We conducted 4-night emergence surveys of 40 4×4 m plots over a 5-night period on the Coromandel Peninsula. Overall detection probability across the survey period was 0.32 (± 0.07 SE) and was highest on wet nights or after rain (0.62 ± 0.11 SE) compared with nights with dry conditions (0.02 ± 0.02 SE). Overall Archey's frog occupancy across all plots was 0.60 (± 0.09 SE) and was highest at plots dominated by woody vegetation (0.92 ± 0.08 SE). An optimal monitoring programme design can be achieved with three repeat surveys of 115 plots if surveys are undertaken within 24 hours of rain. If surveys are undertaken in a mix of dry and wet conditions, then up to 6 repeat surveys of 134 plots may be needed. This study indicates that site occupancy has good potential as a method for monitoring low-density Archey's frog populations.

2.9 Is rapid colour change in Raukawa geckos (*Woodworthia maculata*) an effective defence against avian predators?

F. Kelly[1], S. Herbert[1,2] V. Cave[3] and N. Nelson[1]

[1] School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand
pittosporum2003@yahoo.co.nz

[2] Wildland Consultants, Porirua, New Zealand

[3] AgResearch Ltd, Ruakura Research Centre, Hamilton, New Zealand

Before mammals were introduced, birds and reptiles were the main predators of Aotearoa New Zealand geckos. We have previously demonstrated that, when presented with model avian predators or their calls, Raukawa geckos (*Woodworthia maculata*) exhibited rapid colour change in their tails, with increased levels of contrast and brightness. We proposed this as an antipredator defence mechanism. Diverting a predator's attention to the readily autotomisable (self-induced loss of a body part) tail through rapid colour change in this area, could increase a gecko's chance of escape from a predation attempt. We used trail cameras and model lizards coated in clay to test whether increased levels of brightness and/or contrast in the tail resulted in an increased probability of avian attack on a gecko's tail compared with other body parts. Our three treatments were: tails the same colour and brightness as the rest of the body, brighter tails, and more highly contrasted tails. Trail camera photographs were not an effective method of capturing avian predator attack behaviour, but we were able to deduce their behaviour from peck marks left in the clay. We investigated which body part was most frequently attacked for each model. In models with brighter or more contrasted tails, this was never the head, and most often the tail (at nearly twice the rate of the models with plain tails). Rapid colour change appears to be an effective defence response for Raukawa geckos when approached by an avian predator.

2.10 Living together: social responses and accommodations amongst McCann's skinks (*Oligosoma maccanni*) in a rural garden

J. Kelly

Trustee of Central Otago Ecological Trust, Wanaka, New Zealand
erroljank@gmail.com

Observations over several years show that McCann's skinks have a range of behaviours that allow them to accommodate each other's presence and inhabit a shared space in a range of complex ways where physical closeness is not the daily norm, careful avoidance is like the steps in a dance, and damaging physical fights are a rarity. Hierarchies have built up, with the best refuges being taken by adult females that defend their sites throughout pregnancy but don't exclusively own the space. The author shows how these adjustments can work in practice, uncovering an unexpected level of pragmatism.

2.11 Survey, taxonomy and research on four newly discovered lizard taxa in Oteake Conservation Park, Otago: progress and future directions

C. Knox[1] and J. Monks[2]

[1] Wildland Consultants Ltd, Dunedin, New Zealand
Carey.Knox@wildlands.co.nz

[2] Department of Conservation, Dunedin, New Zealand

Four undescribed lizard species were recently identified from Oteake Conservation Park, including three skinks – Oteake skink, alpine rock skink and rockhopper skink (all *Oligosoma* spp.) – and hura te ao gecko (*Mokopirirakau galaxias*). These taxa have been assessed morphologically and genetically, supporting likely species status. Type specimens have been collected and formal species descriptions prepared. Through extensive survey work since 2018, much has

been learnt about the taxonomic status, distribution, abundance, habitat use and conservation requirements of the new taxa.

- Oteake skink is restricted to boulderfield habitats with overgrowing dense snow tōtara (*Podocarpus nivalis*), which may represent historical fire refugia. These habitats are generally sparse or altogether absent throughout most of Oteake Conservation Park and adjacent land. The largest remaining population is in the Little Kyeburn catchment where they occupy an area of up to 25 hectares.
- The hura te ao gecko is known from small areas in two separate mountain ranges, where it occupies both rock tors and boulderfields within elevations of 1300–1600 m a.s.l.
- Alpine rock skink is a relative of the scree skink (*Oligosoma waimatense*), but is clearly distinguishable, maintains strong morphological differences, and shows no signs of hybridisation in an area where the two taxa overlap. Alpine rock skinks are reasonably widespread in the southern Hawkdun Range and the Ida Range; however, more survey work is needed to determine just how widespread they are and how their distribution and habitat-use compares with that of scree skink.
- Rockhopper skink occupies the edges of alpine screes and boulderfields between c. 1300–1600 m a.s.l. in at least three mountain ranges within Oteake Conservation Park. Rockhopper skink is clearly a new species and overlaps with the distantly related Nevis skink (*Oligosoma toka*) in the Saint Bathans Range.

All four taxa have since been recognised in the 2021 lizard NZTCS assessment. A taxonomic description for hura te ao gecko has been published, and taxonomic descriptions for the skink species are in progress. A research project on hura te ao gecko is underway. Survey work to further assess abundance, distribution, and habitat use is ongoing.

2.12 Collection, characterisation and cryopreservation: a pilot study on tuatara (*Sphenodon punctatus*) sperm suggests unique traits

S. Lamar[1], N. Nelson[1], J. Moore[2], H. Taylor[3,4], S. Keall[1] and D. Ormsby[5]

[1] Centre for Biodiversity and Restoration Ecology, Victoria University of Wellington, Wellington, New Zealand
sarah.lamar@vuw.ac.nz

[2] Biology Department, Grand Valley State University, Allendale, Michigan, USA

[3] Royal Zoological Society of Scotland, Edinburgh, Scotland

[4] Department of Anatomy, University of Otago, Dunedin, New Zealand

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

Despite the importance of successful reproduction to the persistence of at-risk species, there remain large gaps in our understanding of wild species' reproductive characteristics, particularly among reptiles. Tuatara (*Sphenodon punctatus*) are the sole surviving members of the reptile order Rhynchocephalia and are considered taonga (treasure) for many Māori. Once widespread over Aotearoa New Zealand, numbers of tuatara declined following human arrival. While extensive conservation has improved their long-term outlook, there remain significant gaps in our understanding of the reproductive characteristics of male tuatara. In February–March of 2019 we undertook a pilot study on Takapourewa/Stephens Island, where the largest and most dense population of tuatara persists. This research developed a method for semen collection from live, wild tuatara and described mature tuatara sperm for the first time. Further, we began preliminary work developing a long-term storage protocol for tuatara sperm, which could aid in both assisted reproduction, if needed, and future genetic security of this important species. Tuatara sperm samples, particularly those collected during or immediately after courting, have the potential for a very high percentage of viable sperm cells (98%). Scanning electron microscopy revealed a filiform sperm cell with distinct divisions: head, midpiece (often found damaged following cryopreservation trials), tail, and reduced end piece. Finally, our initial curvilinear velocity estimates for tuatara sperm are 2–4 times faster than for any previously studied reptile. Further work is needed to examine these trends at a larger scale; however, this research provides valuable information regarding tuatara reproduction.

2.13 Improving the conservation outcomes of mitigation translocations

O. Lennon[1,2], H. Wittmer[2] and N. Nelson[2]

[1] Wellington Zoo, Wellington, New Zealand
ox.lennon@wellingtonzoo.com

[2] Victoria University of Wellington, Wellington, New Zealand

Anthropogenic habitat loss and degradation adversely affect wildlife worldwide. One strategy employed to reduce these negative impacts is mitigation translocation – the movement of wildlife away from development sites. Collaborative mitigation translocations represent a huge opportunity for conservation due to their increasing prevalence and the opportunity to access a different stream of funding. However, mitigation translocations generally aim to fulfil regulatory requirements rather than solely to provide conservation benefit. We investigated mitigation translocations' effectiveness for conservation. We collaborated on a translocation of endemic lizards at a major road construction. Lizards were salvaged over several years, released, and the release sites monitored over 3 years. Low numbers of individuals salvaged and deviations from management plans hindered pre-release phases, meaning the conservation impact of the translocation is likely low. Additionally, we revisited mitigation translocations of Aotearoa New Zealand lizards and took surveys of populations at release sites to determine their success over the medium term (7–14 years post-translocation). We found success rates were lower than for conservation translocations. Contracted ecologists are aware of conservation best practices, but often lack a mandate to implement these in mitigation translocations, due in part to the differences between mitigation and conservation goals. We make recommendations for improving the legal and regulatory underpinnings, as well as practice, of mitigation translocations.

2.14 What effect does an increasing male bias have on territorial patterns of tuatara?

L. Liu[1], K. Grayson[2] and N. Nelson[1]

[1] School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand
liulinlin318@outlook.com

[2] Department of Biology, University of Richmond, Richmond, Virginia, USA

Sex ratio is a critical parameter for population dynamics and evolutionary ecology as it can influence sexual competition and mate choice and, ultimately, population viability. Species with temperature-dependent sex determination (TSD) are prone to sex ratio variations. Tuatara, the only known species with a rare TSD pattern where males hatch from high temperatures, are particularly at risk of an extreme male bias and ensuing population

decline due to the production of fewer offspring. Consequences of a male population bias for territoriality, and therefore resource availability (such as for food and mates) are not known for tuatara but are speculated to be detrimental for population viability. There has been an increasing male bias in the tuatara population on North Brother Island since the late 1990s, together with declining body condition and population size.

We investigated how an increasing male bias drives changes in territorial patterns of the North Brother Island tuatara population with 30 years of survey data, and its implications for individual fitness correlates and population viability. Territorial patterns were compared with less-dense translocated populations (on Long Island and Matiu/Somes Island) to explore the effects of density on territorial patterns.

Preliminary results indicate that males have larger territories than females, and territory size decreases and overlap between sexes increases with increasing male bias. Territory size on North Brother Island is smaller than on Long and Matiu/Somes Islands.

Increasing male bias appears to drive population decline through intensified resource competition and male dominance over resources, which cause negative impacts on individual fitness, especially for females.

2.15 Assessing translocation outcomes for three lizard species on a Hauraki Gulf / Tīkapa Moana island

S. Melzer and M. Rixon

Auckland Council, Auckland, New Zealand
sabine.melzer@aucklandcouncil.govt.nz

Lizards (74 *Oligosoma smithi* in 2010, 30 *Woodworthia maculata* in 2010 and 31 *Dactylocnemis pacificus* in 2014) were released onto a 0.7 ha island in the Hauraki Gulf to restore ecosystem function, increase the spatial distribution of these species in the Auckland Region, and promote conservation. Mice were removed from the island between 1996 and 2001 and an intensive survey in 2006 showed no reptiles were present on the island before the translocations. Species were monitored annually for evidence of survival and recruitment using ACOs (artificial cover objects) and CFRs (cell foam retreats). All three species have shown survival and consistent breeding, and all life stages are regularly observed. Breeding by second generation individuals could be conclusively shown only for *D. pacificus*, where photo ID was used to identify individuals where possible. Out of the 31 Pacific gecko founders, 15 were recaptured at least once between 2014 and 2020. Since 2016, 25–55% of captured females were gravid. One adult female was recaptured gravid under the same cover for 4 years. Since 2018, more island-born *D. pacificus* than founders were recorded. Three years after release, more *W. maculata* were captured than had been released and by 2020 the population had more than doubled. While *O. smithi* have been consistently breeding, numbers captured are the lowest of all three species, with no more than 65% of the total number of skinks released in 2010 ever captured. Results will be discussed in the context of the standardised definition of translocation success by Miller et al. 2014.

2.16 Evidence of predation by mammals on alpine lizards in Aotearoa New Zealand

J. Monks[1], J. McAulay[2], N. Foster[3], A. Bertoia[3] and K. Sidaway[1]

[1] Department of Conservation, Dunedin, New Zealand
jmonks@doc.govt.nz

[2] Department of Conservation, Te Anau, New Zealand

[3] Department of Zoology, University of Otago, Dunedin, New Zealand

Species living in alpine zones are threatened by habitat loss, predation and climate change. Alpine zones cover c. 11% of Aotearoa and support rich faunal communities including at least 33 lizard species of which c. 75% are considered Threatened or At Risk under the New Zealand Threat Classification System. There is a perception among some herpetologists that high-altitude lizard sites are rarely visited by mammalian predators. A review of evidence of the impacts of introduced mammalian predators on alpine fauna in Aotearoa found little information about alpine lizards (O'Donnell et al. 2017) and only one instance of direct evidence of predation on an alpine lizard species (Cascade gecko; *Mokopirirakau* "Cascades"). Alpine research in Aotearoa New Zealand has proliferated recently, including studies on altitudinal limits of predators, diet of stoats, and evaluation of behaviour and potential monitoring tools for alpine lizards. We collated information from these studies to further build the picture of predator impacts on alpine lizards. In all studies investigated (ranging from Kahurangi National Park in the north of the South Island to Fiordland in the south) we found either direct evidence of mammalian predation on alpine lizards or evidence of predators being present in the same place at the same time as alpine lizards.

Our work adds to the growing body of evidence for the potential impact of mammalian predators on alpine fauna in Aotearoa New Zealand and a need to understand population-level impacts of predators on native alpine lizards.

2.17 Understanding predator-prey interactions for restoring Aotearoa New Zealand lizards

G. Norbury

Manaaki Whenua – Landcare Research, Alexandra, New Zealand
NorburyG@landcareresearch.co.nz

Aotearoa New Zealand lizard numbers are broadly driven by bottom-up (habitat and food) and top-down (predation) processes. This study used density-dependent predation theory as a conceptual framework for predicting the outcomes of manipulating these processes for restoring lizard populations. The numerical and functional responses of introduced predators in Aotearoa New Zealand are driven largely by introduced primary prey (rodents and rabbits), not by lizards. This decouples predator dynamics from those of lizards and allows predators to drive them to extinction. Predation theory predicts that predator control will achieve little or no lizard responses above threshold predator densities. Below these densities, divergent lizard responses are predicted: lizards either fail to respond or their numbers recover to high levels. Empirical evidence (as predator density-impact functions) that support these predictions is presented.

Predation theory also predicts indirect benefits of improving lizard habitat, which affects predators' numerical and functional responses. Increasing the structural complexity of habitat increases refuge for lizards and reduces predators' hunting efficiency, or it pushes out predators' primary prey (rabbits), which in turn reduces predator abundance. Predicted outcomes in this case include low stable lizard populations or high populations, with extinctions less likely. However, increased numbers of rodents are a perverse outcome of improving habitat complexity as they usually respond well to habitat improvements. This can have significant negative impacts on lizards. While judicious grazing may alleviate the rodent problem to some extent, it is important to be clear about the lizard species we are trying to protect and how vulnerable they are to rodents compared with top-order predators like mustelids and feral cats.

The importance of predator-free biodiversity 'showcases' in winning the public's 'hearts and minds' for protecting lizards is highlighted in this account, along with some unexpected positive and negative surprises from a community-led predator eradication and lizard translocation project in Central Otago.

2.18 Biodiversity Focus Areas: Auckland Council's role in prioritising biodiversity management in the Auckland Region. What does it mean for Auckland's herpetofauna?

M. Rixon, J. Andrews, S. Melzer and B. Senior

Auckland Council, Auckland, New Zealand
melinda.rixon@aucklandcouncil.govt.nz

Indigenous biodiversity in the Auckland Region is under severe pressure. Only 15% of the original extent of indigenous ecosystems of the area remain. Currently, several hundred flora and fauna species (including 16 terrestrial reptiles and one frog) are thought to be regionally threatened or at risk of extinction. Auckland Council is mandated by various plans and strategies to deliver on two objectives that attempt to reverse these statistics: (1) to conserve the greatest number, and most diverse range, of Auckland's indigenous ecosystems and sequences, and (2) to achieve long-term recovery of the greatest number of threatened species whose range includes the Auckland Region. One means by which Auckland Council is striving to achieve these two objectives is through the development of Biodiversity Focus Areas (BFAs). These represent the *minimum* set of sites requiring targeted management of critical pressures to ensure that regional viability of indigenous ecosystems, sequences and species is maintained over the long term. BFAs guide the delivery of biodiversity management across council-owned land and are being used to assist with planning biodiversity management activities when collaborating with other partners. Most ecosystem BFAs have been mapped, and work is underway to define and map key sites for threatened species. Attempts to prioritise and undertake management for threatened species has resulted in a small number of species seeing some form of targeted management. Knowledge gaps in threatened species distribution and threats, and the identification of key sites, remain for many species. Lizard species and Hochstetter's frog (*Leiopelma hochstetteri*) will be discussed as case studies.

2.19 The impact of Australia's 2019/20 bushfires on amphibians and reptiles: people power to the rescue?

J. Rowley[1,2]

[1] Australian Museum Research Institute, Australian Museum, Sydney, Australia
jodi.rowley@austmus.gov.au

[2] Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, Australia

The bushfires in southeastern Australia during the summer of 2019/20 were unprecedented in their extent and intensity. From September 2019 to January 2020, more than 17 million hectares of forest burnt in Australia. By area, this was the largest fire season in southeastern Australia since European occupation and the impact of these fires on biodiversity is likely to be dramatic. However, there is little information available on the response of most biodiversity, particularly amphibians and reptiles, to fire. As a result, post-fire management decisions have been hindered by a lack of knowledge, with prioritisation efforts based on best guesses rather than empirical evidence. This presentation will give insight into what we know so far about the impact of these fires on Australia's amphibians and reptiles. It will focus on the data gathered rapidly and across a large scale in the wake of these fires via the continental-scale citizen science project – FrogID. Citizen science projects like FrogID, alongside targeted scientific surveys, will be vital to conservation in response to increasing anthropogenically-driven ecological events.

2.20 Does size matter? Using osteology and ancient DNA to reconstruct extinct diversity in Duvaucel's gecko (*Hoplodactylus duvaucelii*)

L. Scarsbrook[1], A. Verry[1], E. Sherratt[2], R. Hitchmough[3] and N. Rawlence[1]

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

[2] School of Biological Sciences, University of Adelaide, Adelaide, Australia

[3] Department of Conservation, Wellington, New Zealand

The dynamic geology and climate of the Aotearoa New Zealand archipelago has had pronounced effects on the evolution of its endemic biota. However, contemporary biodiversity is depauperate, with complex extinction–recolonisation dynamics and cryptic extinctions occurring following the arrival of both Polynesians and Europeans. *Hoplodactylus duvaucelii* (Duvaucel's gecko) is a large Diplodactylidae species previously widespread throughout New Zealand (based on relative-size identification of Holocene subfossils), but with extant populations now restricted to predator-free offshore islands. We used integrated morphological and genetic approaches to reconstruct the taxonomic and phylogeographic diversity of New Zealand's large geckos ('*H.* cf. *duvaucelii*'). Three-dimensional geometric morphometrics was used to characterise and describe maxilla shape and size variation between extant Diplodactylidae genera, and to determine the taxonomic affinities of Holocene '*H.* cf. *duvaucelii*' subfossils. All genera were morphologically distinct – primarily reflecting ecomorphological adaptation; however, relative-size comparisons were only effective in distinguishing *Hoplodactylus* from other Aotearoa New Zealand gecko species. Additionally, while some '*H.* cf. *duvaucelii*' subfossils exhibited strong affinities towards *H. duvaucelii*, others possessed morphological variation not encompassed by extant representatives. Furthermore, ancient mitochondrial genomes

(recovered from Holocene subfossils using a minimally destructive DNA extraction method) were used to test for cryptic extinctions of large Holocene geckos, and to reconstruct phylogeographic structure in *H. duvaucelii*. Absence of large Holocene representatives outside *Hoplodactylus* implies gigantism evolved only once within the Aotearoa New Zealand Diplodactylidae radiation. Pronounced phylogeographic structure was identified within *H. duvaucelii*, with extant populations comprising two deeply divergent and morphologically distinct clades. These results highlight the application of integrated analyses in taxonomy, biogeography and conservation of Aotearoa New Zealand's lizard fauna.

2.21 Does growing old make you grumpy? Personality differences between juvenile and adult Otago skinks (*Oligosoma otagense*)

H. Thompson and S. Godfrey

Department of Zoology, University of Otago, Dunedin, New Zealand
thoho733@student.otago.ac.nz

Animal personality is a collection of repeatable behaviours, such as aggression and boldness, expressed consistently within and across different contexts. Personality traits may alter throughout the lifespan of an animal in response to costs and benefits. Understanding these ontogenetic personality changes aids in understanding how individuals tolerate and act in and towards environments, conspecifics and other animals throughout their lifespan. This behavioural topic remains relatively unexplored for many reptilian species. In this project we aimed to examine whether there is a difference in personality between juvenile, subadult and adult Otago skinks (*Oligosoma otagense*) at Ōrokonui Ecosanctuary (near Dunedin) using photographic surveys and behavioural assays. We hypothesised that personalities would vary between these age groups with increased variation in the personalities of the younger individuals. As demonstrated in other animal personality studies, we predicted that adults would demonstrate increased aggression and decreased boldness and number of passive interactions compared with juveniles and subadults. The findings of this research will increase our understanding of the personality of the endangered Otago skinks and provide further insights into ontogenetic changes in reptile personality.

2.22 The rise and fall of shore skinks: unexpected outcomes of invasive mammal eradication

D. Towns[1], J. Monks[2] and R. Parrish[3]

[1] Auckland University of Technology, Auckland, New Zealand
dtowns@xtra.co.nz

[2] Department of Conservation, Dunedin, New Zealand

[3] Department of Conservation (Retired), New Zealand

Many Aotearoa New Zealand lizard species appear to be vulnerable to the effects of introduced predators. There are now numerous examples of increased abundances and reappearances of lizards after introduced mammalian predators have been removed from islands. We used a long-term (>20-year) pitfall trapping study on Korapuki Island (Mercury Islands), to investigate how shore skinks (*Oligosoma smithi*) respond to unrestricted habitat availability after the removal of kiore (*Rattus exulans*) and rabbits (*Oryctolagus cuniculus*) in 1986–87. After mammal removal, the skinks rapidly underwent habitat and demographic

shifts and these changes were followed by increases in capture frequency, which continued for about 10 years. However, capture frequencies then began to decline, and 23 years after the eradications, captures were equivalent to those before rat and rabbit removal. Comparisons with other islands indicate variable responses to predator removals by shore skinks. The results appear to be counter-intuitive given widely reported lizard abundance increases after pest eradications elsewhere. Our data for Korapuki suggest that pest removal can unleash a cascade of site-specific responses by native species, with some species able to rapidly exploit newly available habitats before the system resets within a new set of interactive boundaries.

3. Titles and authors of short (5-minute) conference presentations

3.1 Exploring the use of radio-telemetry to study the behaviour and movements of Aotearoa New Zealand's native frogs

J. Altobelli[1], P. Bishop[1] and K. Dickinson[2]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand
altjo375@student.otago.ac.nz

[2] Department of Botany, University of Otago, Dunedin, New Zealand

3.2 James Fawcett Fund for Herpetological Research

R. Bray

Tāmaki Paenga Hira Auckland War Memorial Museum, Auckland, New Zealand
rbray@aucklandmuseum.com

3.3 Pathogen prevalence and diversity in native and invasive Aotearoa New Zealand lizards

R. Butcher[1], B. Gartrell[1], M. Baling[2] and K. McInnes[3]

[1] Wildbase, Massey University, Palmerston North, New Zealand
r.g.butcher@massey.ac.nz

[2] School of Environmental and Animal Sciences, Unitec Institute of Technology, Auckland, New Zealand

[3] Department of Conservation, Wellington, New Zealand

3.4 Low-carbon herpetology in the climate emergency: how are we tracking?

A. Cree

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

3.5 Quantifying translocation and habitat enhancement techniques for reptiles in salvage translocations

J. Fairbrother-Lambert[1], J. Germano[2] and M. Barry[1]

[1] School of Natural and Computational Science, Massey University, Palmerston North, New Zealand
jmfairbro@massey.ac.nz

[2] Department of Conservation, Nelson, New Zealand

3.6 Diversity of endoparasites in exotic herpetofauna

W. Fajardo[1], K. Naden[1], D. van Winkel[2] and M. Baling[1]

[1] School of Environmental and Animal Sciences, Unitec Institute of Technology, Auckland, New Zealand
Fajardo.warrenanne@gmail.com

[2] Bioresearches Group Ltd, Auckland, New Zealand

3.7 Ex-situ management of the West Coast's most imperilled skinks

R. Gibson and S. Brill

Auckland Zoo, Auckland, New Zealand
richard.gibson@aucklandzoo.co.nz

3.8 Observations on the natural history of the northern striped gecko

R. Gibson[1], J. Spencer[1] and S. Smerdon[2]

[1] Auckland Zoo, Auckland, New Zealand
richard.gibson@aucklandzoo.co.nz

[2] Mahakirau Forest Estate Society Inc, New Zealand

3.9 Social behaviour in New Zealand lizards

S. Godfrey

Department of Zoology, University of Otago, Dunedin, New Zealand
stephanie.godfrey@otago.ac.nz

3.10 Behavioural response of Archey's frogs to predator scent

H. Goodman[1], D. McFarlane[2], R. Gibson[2] and M. Baling[1]

[1] School of Environmental and Animal Sciences, Unitec Institute of Technology, Auckland, New Zealand
Hollygrace922000@hotmail.co.nz

[2] Auckland Zoo, Auckland, New Zealand

3.11 Site occupancy monitoring of Hochstetter's frog (*Leiopelma hochstetteri*) at Otawa Frog Sanctuary, Te Puke: year one results

A. Haigh[1], R. Burns[2], P. Stewart[3]and B. Angus[4]

[1] Department of Conservation, Taupō, New Zealand
ahaigh@doc.govt.nz

[2] Department of Conservation, Rotorua, New Zealand

[3] Red Admiral Ecology, Coromandel, New Zealand

[4] Department of Conservation, Tauranga, New Zealand

3.12 Investigating arboreal behaviour in Chesterfield skinks

M. Kerrigan[1], D. McFarlane[2], R. Gibson[2] and M. Baling[1]

[1] School of Environmental and Animal Sciences, Unitec Institute of Technology, Auckland, New Zealand
marcelkerrigan5@gmail.com

[2] Auckland Zoo, Auckland, New Zealand

3.13 Investigating the use of AI-based image identification to monitor wild cryptic lizards

P. Raphanaud[1], M. Baling[2] and F. Ceacero[1]

[1] Faculty of Tropical AgriSciences, Czech University of Life Sciences, Prague, Czech Republic
pauline.raphanaud@gmail.com

[2] School of Environmental and Animal Sciences, Unitec Institute of Technology, Auckland, New Zealand

3.14 Long-term dispersal of soft- and hard-released jewelled geckos (*Naultinus gemmeus*) at Orokonui Ecosanctuary

E. Richardson[1], S. Godfrey[1], A. Cree[1] and J. Monks[2]

[1] Department of Zoology, University of Otago, Dunedin, New Zealand
123ellenrichardson@gmail.com

[2] Department of Conservation, Dunedin, New Zealand

4. Literature cited

Knox, C.; Hitchmough, R.A.; Nielsen, S.V.; Jewell, T.; Bell, T. 2021: A new, enigmatic species of black-eyed gecko (Reptilia: Diplodactylidae: *Mokopirirakau*) from North Otago, New Zealand. *Zootaxa 4964(1)*: 140–156. https://doi.org/10.11646/zootaxa.4964.1.7

Miller, K.A.; Bell, T.P.; Germano, J.M. 2014: Understanding publication bias in reintroduction biology by assessing translocations of New Zealand's herpetofauna. *Conservation Biology 28(4)*: 1045–1056. https://doi.org/10.1111/cobi.12254

O'Donnell, C.F.J.; Weston, K.A.; Monks, J.M. 2017: Impacts of introduced mammalian predators on New Zealand's alpine fauna. *New Zealand Journal of Ecology 41(1)*: 1–22. https://doi.org/10.20417/nzjecol.41.18

Rowley, J.J.L.; Callaghan, C.T.; Cornwell, W.K. 2020: Widespread short-term persistence of frog species after the 2019–2020 bushfires in eastern Australia revealed by citizen science. *Conservation Science and Practice 2020(2)*: e287. https://doi.org/10.1111/csp2.287

Scarsbrook, L.; Sherratt, E.; Hitchmough, R.A.; Fordyce, R.E.; Rawlence, N.J. 2021: Skeletal variation in extant species enables systematic identification of New Zealand's large, subfossil diplodactylids. *BMC Ecology and Evolution 21*: 67. https://doi.org/10.1186/s12862-021-01808-7

Veale, A.J.; de Lange, P.; Buckley, T.R.; Cracknell, M.; Hohaia, H.; Parry, K.; Raharaha-Nehemia, K.; Reihana, K.; Seldon, D.; Tawiri, K.; Walker, L. 2019: Using te reo Māori and ta re Moriori in taxonomy. *New Zealand Journal of Ecology 43(3)*: 3388. https://dx.doi.org/10.20417/nzjecol.43.30