

Chapter 1

Synthesising Our Current Knowledge of New Zealand Lizards

David G. Chapple

Abstract The New Zealand lizard fauna, comprising of skinks (Scincidae: Eugongylineae) and geckos (Diplodactylidae), is the most diverse squamate reptile assemblage of any cool temperate region on Earth. It is characterised by its ecological, evolutionary and physiological diversity, rather than its morphological diversity. New Zealand lizards have traditionally been underappreciated, and the recognised fauna (both described and undescribed) has almost trebled since the 1980s, from 38 to 104 taxa. A range of factors have delayed research and broader recognition of the New Zealand lizard fauna, particularly the fact that 45 % of recognised species remain undescribed. This book brings together the world's leading experts on this group of lizards to produce the first authoritative overview of the history, fossil record, taxonomy, biogeography, ecology, life history and reproduction, diseases, physiology, sampling methods and conservation of New Zealand lizards. In doing so, it highlights what is currently known, what is not and where future research efforts should be directed. It is hoped that by showcasing New Zealand lizards and the diverse array of ecological, evolutionary and physiological adaptations that the fauna possesses, the book will stimulate research on this group of lizards, particularly in the areas of greatest need or importance.

Keywords Biogeography • Conservation • Disease • Ecology • Fossil record • Gecko • Life history • Physiology • Reproduction • Sampling methods • Skink • Species discovery • Taxonomy

1.1 The New Zealand Lizard Fauna

Nestled in the south-west Pacific, New Zealand is a large archipelago that displays the faunal signatures of both its Gondwanan origins and more recent oceanic influences (Daugherty et al. 1993; Gibbs 2006). New Zealand was one of the last

D.G. Chapple (✉)
School of Biological Sciences, Monash University, 25 Rainforest Walk, Clayton, VIC 3800,
Australia
e-mail: David.Chapple@monash.edu

countries on Earth to be discovered, and likewise, the full extent of the faunal diversity present within the archipelago is only just starting to be appreciated. This is no better exemplified than in lizards, with just 38 species (21 skinks, 17 geckos) recognised in the early 1980s (Newman 1982). This number has now increased to 104 extant species that are formally, or informally, recognised (61 skinks, 43 geckos; Hitchmough et al. 2016a, b). Whilst this ranks the native lizard fauna of New Zealand as one of the most diverse squamate reptile assemblages of any cool, temperate region on Earth, this diversity, along with the vast array of ecological, evolutionary and physiological adaptations exhibited by New Zealand lizards, has been largely underappreciated, both within the country and beyond its shores.

The presence of the tuatara (*Sphenodon punctatus*) in New Zealand, the sole survivor of a once diverse reptilian order (Cree 2014), may have diverted attention from the lizard fauna. After all, the New Zealand lizard fauna comprises skinks (Scincidae; Eugongylinae) and geckos (Diplodactylidae), which are common and widespread throughout the world, particularly in the Australasian and Pacific regions (Pianka and Vitt 2003; Wilson and Swan 2013; Cogger 2014). Our limited knowledge of New Zealand lizards might also be a matter of numbers; a relatively small human population (4.68 million as at April 2016; http://www.stats.govt.nz/tools_and_services/population_clock.aspx) means that there are comparatively few researchers to study such a diverse fauna. Indeed, there are only eight universities in New Zealand, though a substantial proportion of herpetological research has been conducted by government agencies (e.g. Department of Conservation, Landcare Research or the former Ecology Division, Department of Scientific and Industrial Research and Wildlife Service) and environmental consultants.

Whilst these factors have limited the volume of research that has been conducted on New Zealand lizards, much of what is known is also not freely available as it is contained within unpublished student theses, government reports, environmental consultant reports and other grey literature (Whitaker and Thomas 1989). Some information still remains in people's filing cabinets, on their computers or locked away in their minds. This book aims to collate all of this scattered knowledge into a single location and synthesise it into the first comprehensive summary of New Zealand's remarkable lizard fauna. It brings together the world's leading experts on the group to produce an authoritative overview of the history, fossil record, taxonomy, biogeography, ecology, life history and reproduction, diseases, physiology, sampling methods and conservation of New Zealand lizards. In doing so, it highlights what is known, what is not and where future research should be directed.

Unfortunately, no book on New Zealand lizards can escape the taxonomic impediment that currently exists. Museums, traditionally the drivers of taxonomic research throughout the world, have been strangely silent on New Zealand lizards. Aside from Charles McCann at the Dominion museum (Te Papa Tongarewa, Museum of New Zealand), who completed the only major taxonomic revision for the fauna (McCann 1955), taxonomic research has been left to university and government researchers, or unpaid enthusiasts (Shea 2016; Hitchmough et al. 2016b). Thus, just as it is problematic to study species that you are not

aware exist, it is difficult to enhance your knowledge of a fauna if recognised species actually represent a complex of several species. Extreme examples of this are Hardy's (1977) *Leiopisma nigriplantare maccanni* (McCann's *Leiopisma zelandica*), which is now recognised as 19 distinct taxa, and McCann's (1955) *Hoplodactylus pacificus*, which has since been separated into 21 taxa (Table 1.1 lists the species recognised by McCann (1955) and Hardy (1977) and the taxa that are now recognised within each of these species; also see Chapple and Ritchie (2013)). This has made it difficult to link information between the composite taxa and currently recognised species. Such instances of uncertainty are highlighted throughout each chapter. Although there have been some disparate views on how to deal with the taxonomic impediment in New Zealand lizards (Jewell 2008; Chapple and Hitchmough 2009), all authors in this book follow the taxonomy outlined in the most recent Department of Conservation Threat List for reptiles (Hitchmough et al. 2016a). Since 45 % of the recognised, extant lizard fauna (104 species) remain to be described (Hitchmough et al. 2016b), this book follows the inherent practice in New Zealand of using tag names (e.g. *Dactylocnemis* 'Matapia Island', *Oligosoma* aff. *chloronoton* 'West Otago') when referring to these taxonomically indeterminate (unnamed or undescribed) taxa.

1.2 An Overview of *New Zealand Lizards*

The book comprises 12 contributed chapters covering every aspect of the biology of New Zealand lizards. In Chap. 2, Shea (2016) provides an authoritative overview of the history of discovery of New Zealand lizards, from first contact with Māori through to the present day. He discusses the distinct phases of species discovery and the factors that have influenced our understanding of lizard diversity in New Zealand. The chapter also provides an important historical context within which to consider the biology, ecology and conservation of the native lizard fauna. For instance, the first detailed study of a New Zealand lizard species was not conducted until the 1950s (Barwick 1955, 1959), illustrating just how much knowledge has been generated over the last six decades.

In Chap. 3, Worthy (2016) presents the first comprehensive review of the fossil material that exists for New Zealand lizards. Whilst the pre-Quaternary fossil record for lizards is limited, the Quaternary fossil record provides a vital indication of the prehuman diversity and distribution of New Zealand lizard species and a baseline with which to assess the impact of humans and introduced mammals on the native lizard fauna.

New Zealand lizards are characterised by their ecological and taxonomic, rather than morphological, diversity. Chapter 4 (Hitchmough et al. 2016b) provides an overview of the taxonomy of native skinks and geckos and the recent molecular work that has led to the almost trebling of the known lizard fauna over the last three decades. Chapter 5 (Chapple and Hitchmough 2016) demonstrates that geckos colonised New Zealand during the Eocene or Oligocene (40.2–24.4 mya), prior to

Table 1.1 A comparison of species recognised by McCann (1955) and Hardy (1977), the two major taxonomic reviews for New Zealand lizards and the species that are currently recognised (Hitchmough et al. 2016a, b)

Previous taxonomy	Current taxonomy
McCann (1955)	
Geckos	
<i>Naultinus elegans</i> (4)	<i>Naultinus elegans</i>
	<i>Naultinus punctatus</i>
	<i>Naultinus grayii</i>
	<i>Naultinus</i> ‘North Cape’
<i>Hoplodactylus duvaucelii</i>	<i>Hoplodactylus duvaucelii</i>
<i>Hoplodactylus pacificus</i> (21)	<i>Dactylocnemis pacificus</i>
	<i>Dactylocnemis</i> ‘Matapia Island’ ^a
	<i>Dactylocnemis</i> ‘Mokohinau’
	<i>Dactylocnemis</i> ‘North Cape’
	<i>Dactylocnemis</i> ‘Poor Knights’
	<i>Dactylocnemis</i> ‘Three Kings’
	<i>Toropuku stephensi</i>
	<i>Toropuku</i> ‘Coromandel’ ^a
	<i>Woodworthia chrysosiretica</i> ^a
	<i>Woodworthia maculata</i>
	<i>Woodworthia</i> ‘Central Otago’
	<i>Woodworthia</i> ‘Cromwell’
	<i>Woodworthia</i> ‘Kaikouras’
	<i>Woodworthia</i> ‘Marlborough mini’
	<i>Woodworthia</i> ‘Mount Arthur’
<i>Woodworthia</i> ‘Otago/Southland large’	
<i>Woodworthia</i> ‘pygmy’ ^a	
<i>Woodworthia</i> ‘Southern Alps’	
<i>Woodworthia</i> ‘southern mini’	
<i>Woodworthia</i> aff. <i>maculata</i> ‘Muriwai’ ^a	
<i>Woodworthia</i> cf. <i>brunnea</i>	
<i>Hoplodactylus granulatus</i> (8)	<i>Mokopirirakau granulatus</i>
	<i>Mokopirirakau</i> ‘Cascades’ ^a
	<i>Mokopirirakau</i> ‘Cupola’ ^a
	<i>Mokopirirakau</i> ‘Okarito’
	<i>Mokopirirakau</i> ‘Open Bay Islands’ ^a
	<i>Mokopirirakau</i> ‘Roys Peak’ ^a
	<i>Mokopirirakau</i> ‘southern forest’
<i>Mokopirirakau</i> ‘southern North Island’	
<i>Heteropholis rudis</i>	<i>Naultinus rudis</i>
<i>Heteropholis tuberculatus</i>	<i>Naultinus tuberculatus</i>
<i>Heteropholis gemmeus</i>	<i>Naultinus gemmeus</i>
<i>Heteropholis stellatus</i>	<i>Naultinus stellatus</i>
<i>Heteropholis nebulosus</i>	<i>Mokopirirakau nebulosus</i>

(continued)

Table 1.1 (continued)

Previous taxonomy	Current taxonomy
<i>Heteropholis manukanus</i>	<i>Naultinus manukanus</i>
Not discovered in 1955/recognised by McCann	<i>Tukutuku rakiurae</i>
	<i>Mokopirirakau cryptozoicus</i>
	<i>Mokopirirakau kahutarae</i>
	<i>Hoplodactylus delcourti</i>
Skinks	
<i>Leiopisma grande grande</i>	<i>Oligosoma grande</i>
<i>Leiopisma grande otagense</i>	<i>Oligosoma otagense</i>
<i>Leiopisma grande waimatense</i>	<i>Oligosoma waimatense</i>
<i>Leiopisma fallai</i>	<i>Oligosoma fallai</i>
<i>Leiopisma homalonotum</i>	<i>Oligosoma homalonotum</i>
<i>Leiopisma suteri</i>	<i>Oligosoma suteri</i>
<i>Leiopisma oliveri</i> (2)	<i>Oligosoma oliveri</i>
	<i>Oligosoma townsi</i>
<i>Leiopisma smithi smithi</i> (2)	<i>Oligosoma smithi</i>
	<i>Oligosoma smithi</i> ‘Three Kings, Te Pahi, Western Northland’
<i>Leiopisma smithi numerale</i>	<i>Oligosoma smithi</i>
<i>Leiopisma festivum</i>	<i>Oligosoma lineoocellatum</i>
<i>Leiopisma aeneum</i> (3)	<i>Oligosoma aeneum</i>
	<i>Oligosoma hardyi</i>
	<i>Oligosoma levidensum</i>
<i>Leiopisma moco</i>	<i>Oligosoma moco</i>
<i>Leiopisma zelandica</i> (19)	<i>Oligosoma polychroma</i>
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 2’
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 3’
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 4’
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 5’
	<i>Oligosoma inconspicuum</i>
	<i>Oligosoma</i> aff. <i>inconspicuum</i> ‘North Otago’ ^a
	<i>Oligosoma</i> aff. <i>inconspicuum</i> ‘Okuru’ ^a
	<i>Oligosoma burganae</i>
	<i>Oligosoma toka</i> ^a
	<i>Oligosoma repens</i> ^a
	<i>Oligosoma longipes</i> ^a
	<i>Oligosoma</i> aff. <i>longipes</i> ‘Southern’ ^a
	<i>Oligosoma</i> aff. <i>longipes</i> ‘Rangitata’ ^a
	<i>Oligosoma maccanni</i>
	<i>Oligosoma notosaurus</i>
	<i>Oligosoma stenotis</i>
	<i>Oligosoma tekakahu</i> ^a
	<i>Oligosoma microlepis</i> ^a

(continued)

Table 1.1 (continued)

Previous taxonomy	Current taxonomy
<i>Leiopisma ornatum</i> (2)	<i>Oligosoma ornatum</i>
	<i>Oligosoma zelandicum</i>
<i>Leiopisma dendyi</i>	<i>Oligosoma nigriplantare</i>
<i>Leiopisma turbotti</i>	<i>Oligosoma nigriplantare</i>
<i>Leiopisma lineoocellatum</i> (6)	<i>Oligosoma lineoocellatum</i>
	<i>Oligosoma</i> aff. <i>lineoocellatum</i> ‘South Marlborough’
	<i>Oligosoma</i> aff. <i>lineoocellatum</i> ‘Mackenzie Basin’
	<i>Oligosoma</i> aff. <i>lineoocellatum</i> ‘Central Canterbury’
	<i>Oligosoma chloronoton</i>
	<i>Oligosoma</i> aff. <i>chloronoton</i> ‘West Otago’
<i>Leiopisma latilinearum</i>	<i>Oligosoma striatum</i>
<i>Leiopisma infrapunctatum</i> (8)	<i>Oligosoma infrapunctatum</i>
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Alborn’ ^a
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Chesterfield’ ^a
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘cobble’ ^a
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘crenulate’
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Hokitika’
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Southern North Island’
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Westport’
<i>Sphenomorphus pseudornatus</i> (3)	<i>Oligosoma ornatum</i>
	<i>Oligosoma roimata</i>
	<i>Oligosoma aeneum</i>
Not discovered in 1955/recognised by McCann	<i>Oligosoma judgei</i>
	<i>Oligosoma pikitanga</i>
	<i>Oligosoma taumakae</i>
	<i>Oligosoma</i> ‘Whirinaki’
	<i>Oligosoma</i> sp. ‘Homer Tunnel’
	<i>Oligosoma northlandi</i> (extinct)
	<i>Oligosoma acrinasum</i>
	<i>Oligosoma alani</i>
	<i>Oligosoma macgregori</i>
	<i>Oligosoma whitakeri</i>
Hardy (1977)—skinks	
<i>Cyclodina aenea</i> (3)	<i>Oligosoma aeneum</i>
	<i>Oligosoma hardyi</i>
	<i>Oligosoma levidensum</i>
<i>Cyclodina alani</i>	<i>Oligosoma alani</i>
<i>Cyclodina macgregori</i>	<i>Oligosoma macgregori</i>
<i>Cyclodina oliveri</i> (2)	<i>Oligosoma oliveri</i>
	<i>Oligosoma townsi</i>
<i>Cyclodina ornata</i> (2)	<i>Oligosoma ornatum</i>

(continued)

Table 1.1 (continued)

Previous taxonomy	Current taxonomy
	<i>Oligosoma roimata</i>
<i>Cyclodina whitakeri</i>	<i>Oligosoma whitakeri</i>
<i>Leiopisma acrinasum</i>	<i>Oligosoma acrinasum</i>
<i>Leiopisma chloronoton</i> (2)	<i>Oligosoma chloronoton</i>
	<i>Oligosoma</i> aff. <i>chloronoton</i> ‘West Otago’
<i>Leiopisma fallai</i>	<i>Oligosoma fallai</i>
<i>Leiopisma grande</i>	<i>Oligosoma grande</i>
<i>Leiopisma homalonotum</i>	<i>Oligosoma homalonotum</i>
<i>Leiopisma gracilicorpus</i>	<i>Oligosoma homalonotum</i>
<i>Leiopisma infrapunctatum</i> (8)	<i>Oligosoma infrapunctatum</i>
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Alborn’ ^a
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Chesterfield’ ^a
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘cobble’ ^a
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘crenulate’
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Hokitika’
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Southern North Island’
	<i>Oligosoma</i> aff. <i>infrapunctatum</i> ‘Westport’
<i>Leiopisma lineoocellatum</i> (4)	<i>Oligosoma lineoocellatum</i>
	<i>Oligosoma</i> aff. <i>lineoocellatum</i> ‘South Marlborough’
	<i>Oligosoma</i> aff. <i>lineoocellatum</i> ‘Mackenzie Basin’
	<i>Oligosoma</i> aff. <i>lineoocellatum</i> ‘Central Canterbury’
<i>Leiopisma moco</i>	<i>Oligosoma moco</i>
<i>Leiopisma nigriplantare nigriplantare</i>	<i>Oligosoma nigriplantare</i>
<i>Leiopisma nigriplantare maccanni</i> (19)	<i>Oligosoma polychroma</i>
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 2’
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 3’
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 4’
	<i>Oligosoma</i> aff. <i>polychroma</i> ‘Clade 5’
	<i>Oligosoma inconspicuum</i>
	<i>Oligosoma</i> aff. <i>inconspicuum</i> ‘North Otago’ ^a
	<i>Oligosoma</i> aff. <i>inconspicuum</i> ‘Okuru’ ^a
	<i>Oligosoma burganae</i>
	<i>Oligosoma toka</i> ^a
	<i>Oligosoma repens</i> ^a
	<i>Oligosoma longipes</i> ^a
	<i>Oligosoma</i> aff. <i>longipes</i> ‘Southern’ ^a
	<i>Oligosoma</i> aff. <i>longipes</i> ‘Rangitata’ ^a
	<i>Oligosoma maccanni</i>
	<i>Oligosoma notosaurus</i>
	<i>Oligosoma stenotis</i>
	<i>Oligosoma tekakahu</i> ^a

(continued)

Table 1.1 (continued)

Previous taxonomy	Current taxonomy
	<i>Oligosoma microlepis</i> ^a
<i>Leiopisma otagense</i> form <i>otagense</i>	<i>Oligosoma otagense</i>
<i>Leiopisma otagense</i> form <i>waimatense</i>	<i>Oligosoma waimatense</i>
<i>Leiopisma smithi</i> (2)	<i>Oligosoma smithi</i>
	<i>Oligosoma smithi</i> ‘Three Kings, Te Pahi, Western Northland’
<i>Leiopisma striatum</i>	<i>Oligosoma striatum</i>
<i>Leiopisma suteri</i>	<i>Oligosoma suteri</i>
<i>Leiopisma zelandicum</i>	<i>Oligosoma zelandicum</i>
Not discovered in 1977/recognised by Hardy	<i>Oligosoma judgei</i>
	<i>Oligosoma pikitanga</i>
	<i>Oligosoma taumakae</i>
	<i>Oligosoma</i> ‘Whirinaki’
	<i>Oligosoma</i> sp. ‘Homer Tunnel’
	<i>Oligosoma northlandi</i> (extinct)

^aA new discovery since 1955 or 1977, but has phylogenetic affinities with a taxon that was part of a composite species that was recognised in 1955 or 1977

Numbers in parentheses highlight the number of species now recognised that originally formed part of each composite taxon. Refer to Hitchmough et al. (2016b) for further details and explanation

the ‘Oligocene drowning’, whilst skinks reached New Zealand during the Miocene (~18.3 mya) via long-distance overwater dispersal from New Caledonia, along the Lord Howe Rise and Norfolk Ridge. Chapter 5 further outlines how biogeographic studies have long been hampered by two key factors: recent range contractions and local extinctions following the introduction of ~31 exotic mammalian species and a limited grasp on the true diversity and distribution of the endemic lizard fauna. It provides an updated perspective on the biogeography of the native lizard fauna, including revised biogeographic categories for each species.

New Zealand lizards occupy a broad range of habitats, from coastal beaches (0 m asl) to alpine scrub and scree (2200 m asl), as well as numerous offshore islands and rock stacks. However, Chap. 6 (Hare et al. 2016) illustrates that basic ecological information is still lacking for the majority of lizard species and that the ecological traits of many species are, by necessity, inferred from closely related, but better-studied, species. The chapter summarises our current knowledge on the diet, activity, behaviour and predators of New Zealand lizards, whilst highlighting a range of interesting ecological traits (e.g. seed dispersal and pollination, vocalisation). Chapter 7 (Cree and Hare 2016) outlines how New Zealand lizards live life in the slow lane (e.g. long-lived, late maturing, low reproductive output) and exhibit a high incidence of traits (e.g. viviparity, long gestations and prolonged pregnancies) that are relatively less common elsewhere in the world.

In Chap. 8, Gartrell (2016) provides the first detailed synthesis of the parasites and diseases of native and captive reptiles in New Zealand. This review provides important information, both for the health of wild populations and for captive populations that are part of conservation programmes. New Zealand possesses an incredibly diverse lizard fauna, particularly given its cool temperate climate. Chapter 9 (Hare and Cree 2016) examines the thermal and physiological adaptations that enable lizards to thrive in New Zealand. Physiology is vitally important for many aspects of conservation management and is likely to increase in importance in the context of current climate change.

New Zealand lizards are often cryptic and difficult to catch. Thus, New Zealand researchers have pioneered the development, or modification, of a wide range of approaches to catch and identify native lizard species. Chapter 10 (Lettink and Hare 2016) outlines the methods used to catch New Zealand lizards, including systematic searching, live trapping and artificial retreats.

Chapter 11 provides an overview of the conservation of New Zealand lizards (Towns et al. 2016). Lizards play a large role in the worldview of Māori, but were poorly appreciated by European settlers. In fact, New Zealand lizards remained without formal protection until the 1980s, an unfortunate delay as 83 % of the fauna is currently listed as threatened or at risk. The chapter summarises conservation efforts over the past three decades, providing case studies of the five skink species that have been continually managed since the 1980s. New Zealand is considered a world leader in species conservation, particularly due to its use of translocations and offshore island sanctuaries. Chapter 12 (Nelson et al. 2016) discusses the use of mainland sanctuaries for lizard conservation in New Zealand. The chapter focuses on two case studies: one in a fenced sanctuary and the other in an unfenced sanctuary. The potential impacts of predatory mammals, birds and invertebrates are examined.

Despite the abundance of exotic lizards (99 species) intercepted entering New Zealand (Chapple et al. 2016a), only one, the plague skink (*Lampropholis delicata*), has successfully established and become invasive. Chapter 13 (Chapple et al. 2016b) outlines the Australian source region for the invasive New Zealand populations, its mechanism of spread across New Zealand, and the biology and ecology of the plague skink within the country. Biosecurity measures to prevent its spread to conservation-sensitive offshore islands are discussed.

In the final chapter (Chapple 2016), the current knowledge of the New Zealand lizard fauna is summarised. A critical assessment of New Zealand lizard research is provided, forming the basis for recommendations for the direction of future research.

References

- Barwick RE (1955) Studies on the scincid lizard, *Leiolopisma zelandica* (Gray, 1843) with notes on *Leiolopisma aeneum* (Girard, 1857). Unpublished MSc thesis, Victoria University of Wellington, New Zealand
- Barwick RE (1959) The life history of the common New Zealand skink *Leiolopisma zelandica* (Gray, 1843). *Trans R Soc N Z* 86:331–380
- Chapple DG (2016) The future of New Zealand lizard research. Chap. 14. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Chapple DG, Hitchmough RA (2009) Taxonomic instability of reptiles and frogs in New Zealand: information to aid the use of Jewell (2008) for species identification. *N Z J Zool* 36:59–71
- Chapple DG, Hitchmough RA (2016) Biogeography of New Zealand lizards. Chap. 5. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Chapple DG, Ritchie PA (2013) A retrospective approach to testing the DNA barcoding method. *PLoS One* 8:e77882. doi:[10.1371/journal.pone.0077882](https://doi.org/10.1371/journal.pone.0077882)
- Chapple DG, Knegtmans J, Kikillus H, van Winkel D (2016a) Biosecurity of exotic reptiles and amphibians in New Zealand: building upon Tony Whitaker’s legacy. *J Roy Soc New Zeal* 46:66–84
- Chapple DG, Reardon JT, Peace JE (2016b) Origin, spread and biology of the invasive plague skink (*Lampropholis delicata*) in New Zealand. Chap. 13. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Cogger HG (2014) *Reptiles and amphibians of Australia*, 7th edn. CSIRO Publishing, Melbourne
- Cree A (2014) *Tuatara: biology and conservation of a venerable survivor*. Canterbury University Press, Christchurch
- Cree A, Hare KM (2016) Reproduction and life history of New Zealand lizards. Chap. 7. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Daugherty CH, Gibbs GW, Hitchmough RA (1993) Mega-island or micro-continent? New Zealand and its fauna. *Trends Ecol Evol* 8:437–442
- Gartrell B (2016) Diseases of New Zealand reptiles. Chap. 8. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Gibbs G (2006) Ghosts of Gondwana. The history of life in New Zealand. Craig Potton, Nelson
- Hardy GS (1977) The New Zealand Scincidae (Reptilia: Lacertilia); a taxonomic and zoogeographic study. *N Z J Zool* 4:221–325
- Hare KM, Cree A (2016) Thermal and metabolic physiology of New Zealand lizards. Chap. 9. In: Chapple DG (ed) *New Zealand Lizards*. Springer, Cham
- Hare KM, Chapple DG, Towns DR, van Winkel D (2016) The ecology of New Zealand’s lizards. Chap. 6. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Hitchmough R, Barr B, Monks J, Lettink M, Reardon J, Tocher M, van Winkel D, Rolfe J (2016a) Conservation status of New Zealand reptiles, 2015. *New Zealand threat classification series*. Department of Conservation, Wellington
- Hitchmough RA, Patterson GB, Chapple DG (2016b) Putting a name to diversity: taxonomy of the New Zealand lizard fauna. Chap. 4. In: Chapple DG (ed) *New Zealand Lizards*. Springer, Cham
- Jewell T (2008) *A photographic guide to reptiles and amphibians of New Zealand*. New Holland, Auckland
- Lettink M, Hare KM (2016) Sampling techniques for New Zealand lizards. Chap. 10. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- McCann C (1955) The lizards of New Zealand. Gekkonidae and Scincidae. *Dominion Mus Bull* 17
- Nelson NJ, Romijn RL, Dumont T, Reardon JT, Monks JM, Hitchmough RA, Empson R, Briskie JV (2016) Lizard conservation in mainland sanctuaries. Chap. 12. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Newman DG (1982) New Zealand herpetology. In: *Proceedings of a symposium held at the Victoria University of Wellington, 29–31 Jan 1980*. New Zealand Wildlife Service occasional publication No. 2, Wellington, 495p

- Pianka ER, Vitt LJ (2003) *Lizards: windows to the evolution of diversity*. University of California Press, Berkeley, CA
- Shea GM (2016) History of discovery of the New Zealand lizard fauna. Chap. 2. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Towns DR, Hitchmough RA, Perrott J (2016) Conservation of New Zealand lizards: a fauna not forgotten but undervalued? Chap. 11. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham
- Whitaker AH, Thomas BW (1989) *New Zealand lizards: an annotated bibliography*. Ecology Division, Department of Scientific and Industrial Research, Lower Hutt
- Wilson S, Swan G (2013) *A complete guide to reptiles of Australia*, 4th edn. Reed New Holland, Sydney
- Worthy TH (2016) A review of the fossil record of New Zealand lizards. Chap. 3. In: Chapple DG (ed) *New Zealand lizards*. Springer, Cham