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Forum

Dynamic taxonomy versus field identification: a dilemma for New Zealand herpetologists

When working scientists strongly disagree about an important matter of general principle, the arguments are often of considerable interest to many others besides those directly involved. Then it becomes useful to the scientific community to be allowed to listen in to the debate, especially when the differences in opinion expressed are deeply held, and more extensive than can be dealt with under the normal rules of confidential refereeing. The two papers contributing to the following Forum supply a clear example of this instructive process.

The stimulus for this exchange was the publication in September 2008 of *A Photographic Guide to Reptiles and Amphibians of New Zealand* by Tony Jewell, with photographs by Rod Morris (New Holland Publishers (NZ) Ltd, Auckland). This little book is one of a series of photographic guides produced by the same publisher to assist the general public to identify New Zealand's fauna and flora. It is not a technical monograph, but obviously, it had to supply names for all the reptiles and amphibians illustrated. That was not easy, because for some years the technical nomenclature of these animals has lagged a long way behind the discovery of new taxa; yet, at the same time, people still want to know what to call the animals that they collect in distribution surveys or rescue from the cat. Jewell's book is the most recent attempt to steer through these conflicting requirements.

Taxonomic revisions usually take considerable time to complete, and are not available until published. Working identifications are needed meanwhile, which have to be updated at frequent intervals as new formal descriptions continue to appear. These near-continuous changes introduce a dilemma for scientists, publishers and the general public. When nomenclatural changes are so pervasive, how can publishers produce accurate identification guides that keep abreast of the changes but do not go out of date too quickly? When there are so many different lizards that look alike but are actually separate, non-interbreeding species, how can scientists help non-specialists identify animals that they have found? A revised and updated field guide to New Zealand reptiles and amphibians is undoubtedly required, but is it possible to produce one that meets this dilemma and still remains useful and economic?

Here, David Chapple and Rod Hitchmough summarise the current state of uncertainty in the technical taxonomy of reptiles and amphibians in New Zealand, and the use of informal 'tag' names to identify unnamed species until they are formally described. While local 'tag' names are not ideal, they are generally informative and stable, at least until the expected generic revisions are produced for both the skinks and geckos. In response, Tony Jewell explains the rationale behind his choices of the informal names that he attached to those photographs in his book.

There is plenty of room for disagreement, and that is of course quite normal in science. The distinguishing feature of scientific disagreements, however, is that they have to be based on rational arguments which other people can digest and discuss. I therefore invited both sides of this dispute to set out their opinions as clearly and logically as possible. I also invited several leading herpetologists to add a third opinion, but without success.

In part this debate illustrates a common problem: books take a long time to produce, and specialised papers published in a fast-moving field can overtake a general compilation before it reaches the bookshops. But should that deter authors and publishers from writing science for general readers? It is especially unfortunate for Jewell that several important papers have published new formal names and updated the

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phylogenies of the New Zealand lizard fauna in the very short space of time since his manuscript went to press in January 2008. Part of the purpose of this Forum is to provide updated information that should help users of the new guide match the visual details given in Rod Morris's photographs, and the information given in Tony Jewell's text, with the current list of names accepted by professional herpetologists.

The ultimate judge of these matters is, as always, the scientific community. Reasoned responses will be considered for future publication, especially if linked to a review of similar debates concerning other taxa.

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Taxonomic instability of reptiles and frogs in New Zealand: information to aid the use of Jewell (2008) for species identification

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INTRODUCTION

New Zealand is home to an extraordinarily diverse herpetofauna. This is quite remarkable given the temperate latitude (34–47°S), cold climate and relatively small land area (c. 270 000 km^2) of the New Zealand archipelago. Indeed, many authorities (e.g., Daugherty et al. 1994; Hickson et al. 2000) consider New Zealand to have the most diverse cool-temperate herpetofauna in the world. Native reptiles and frogs can be found in every available habitat in New Zealand including marine, coastal, grassland, wetland, forest, and alpine bluff and rock scree environments.

All native terrestrial reptile and amphibian species are endemic at the species and generic level, and endemism is also evident at the level of Family (Leiopelmatidae, native frogs) and Order (Sphenodontia, tuatara). Adaptation to cold climates appears to have influenced the evolution of the New Zealand herpetofauna, producing several unusual traits. Most reptile and amphibian species are long-lived (40+ years has been confirmed for several), and all but three (*Oligosoma suteri* and both tuatara species) native terrestrial reptile species are viviparous (including one of only two viviparous lineages of geckos in the world). However, the New Zealand herpetofauna is undoubtedly best known for its archaic element ("living fossils"), the tuatara and Leiopelmatid frogs.

The arrival of humans and the introduction of terrestrial mammals has significantly reduced the geographic distributions and abundances of native reptile and amphibian species, but given that only one reptile species is known to have become extinct since 1840 (Hitchmough et al. 2007), and one other before European settlement (Worthy 1991), species diversity might appear to be largely unchanged. However, we are only just starting to comprehend how diverse the New Zealand herpetofauna actually is. The current field guide to New Zealand's reptiles and amphibians (Gill & Whitaker 2001) recognised 59 extant species (although numerous additional unnamed species were known at that time, they were

not included in the field guide). However, over the past decade numerous putative new species have been discovered in remote regions of the country, many molecular studies have revealed cryptic or overlooked species within widespread taxa, and several taxonomic studies and species descriptions have been published.

Taxonomy is a dynamic field, with regular updates and revisions of nomenclature and in the species that are recognised. Research over the past decade, and in the last 2–3 years in particular, has resulted in substantial changes to the taxonomy of New Zealand reptiles. This research is still ongoing, and it will undoubtedly take several years to formally describe the unnamed species of which we are already aware. However, the dynamic nature of the taxonomy of New Zealand reptiles and amphibians creates quandary for scientists, conservation managers and the general public. The high level of morphological conservatism and the prevalence of cryptic species in New Zealand lizards, coupled with regular taxonomic updates, all make accurate species identification difficult. Compiling a reliable field guide for New Zealand's reptiles and amphibians therefore represents a substantial challenge.

Jewell (2008): a new field guide

The most recent attempt to produce an up-to-date field guide is *A Photographic Guide to Reptiles and Amphibians of New Zealand* by Tony Jewell, with photographs by Rod Morris. It was published by New Holland Publishers (NZ) Ltd, Auckland in 2008, and was intended as a replacement for Gill & Whitaker (2001). It certainly looks the part. It is small (143 pages), compact and portable; exactly what is required when space in a fieldwork backpack is at a premium. It is also inexpensive (NZ$24.99), making it accessible to professional scientists, graduate students, amateur naturalists, and the general public.

Jewell includes all the usual elements of a good field guide, from an introduction and background to the New Zealand herpetofauna, an examination of distribution patterns (highlighting species diversity and endemism at the national and regional level), to a summary of reptile and amphibian biology, habitats, and conservation. The essential terminology is adequately explained, and a glossary is provided at the back of the book. It explains that all native reptile and amphibian species are legally protected under the Wildlife Act 1953, therefore permits are required to collect or undertake research on them, but states incorrectly that introduced species are not protected (p. 13). In fact, all introduced species are protected under the Wildlife Act until they are transferred to another Schedule within the Act. For example, the three species of introduced frog (*Litoria* spp.) are listed under Schedule 5 (as *Hyla* spp.) and are therefore not protected. Unfortunately, the invasive rainbow skink (*Lampropholis delicata*) has not been moved to another Schedule, so has therefore been protected since its introduction to New Zealand in the 1960s, a situation that herpetologists have wanted corrected for many years.

Jewell then provides a brief overview of taxonomy and nomenclature, outlining the distinguishing features of each reptile and amphibian group, and then a taxonomic key with which to identify species to the genus level. Importantly, he has incorporated information from recent species discoveries and published literature, bumping the number of extant reptile and amphibian species recognised to 107. The species descriptions constitute the majority of the field guide, and are organised by Family: geckos (Diplodactylidae), skinks (Scincidae), tuatara (Sphenodontidae), sea snakes (Laticaudidae, Hydrophiidae), turtles (Cheloniidae, Dermochelyidae), and frogs (Leiopelmatidae, Hylidae). Each species summary contains descriptions of colour patterns, key morphological features, body size, and geographic variations.

The majority of the photographs are exceptionally good, and multiple photographs of each species illustrate geographic variations in colour pattern and morphology, and different life stages where applicable. It is the first time that photos (and species summaries) of several recently described or unnamed species have appeared in a field guide. Unfortunately, the poor quality of the distribution maps is a major disappointment. The distribution maps are very small and difficult to read and interpret, and some contain significant errors. Since the book directs readers to the distribution maps to distinguish morphologically similar species (pp. 13–14), the deficiencies in the distribution maps have the potential to inhibit accurate species identification.

Changes to species nomenclature

Jewell has struggled with the numerous recent changes to the existing nomenclature for New Zealand reptiles and amphibians, especially with common names and 'tag' names. The large number of cryptic species uncovered by molecular studies, and the continual discovery of putative new species, means that most undescribed species in New Zealand are known only by a tag name (e.g., *Oligosoma*

'Te Kakahu'). These tag names are generally in common usage and are temporally stable (e.g., they are listed in the New Zealand Threat Classification System, Hitchmough et al. 2007), enabling researchers to accurately identify undescribed taxa. Since taxonomic revisions can take considerable time to complete, tag names provide a means to identify these unnamed species until they are formally described. While tag names are not ideal, they are more informative and stable than arbitrarily numbered undescribed species in each genus, especially since generic revisions are pending for both the skinks and geckos. However, Jewell has chosen not to retain the existing tag names and has instead instituted an alternative system (e.g., *Oligosoma* 'Te Kakahu' is now *Oligosoma* sp. 6; p. 89).

There are existing common names for New Zealand's reptiles and amphibians, but Jewell states that "the opportunity has been taken to suggest new and more appropriate common names that can be used indefinitely" (p. 14). However, not everyone will agree with his allocation of common names. For example, the Open Bay Islands gecko (Genus B: sp. 3; p. 36), that is restricted to the island of Taumaka in the Open Bay Islands retains its common name, while the Open Bay Islands skink (*Oligosoma taumakae*; p. 99), which lives on both major islands in the Open Bay Islands (Taumaka and Popotai; Chapple & Patterson 2007; M. Lettink, pers. comm.) is renamed the Taumaka skink.

Jewell emphasises that "An accurate understanding of diversity underpins all aspects of research into our reptiles and amphibians. Yet as knowledge about diversity advances, the known fauna is becoming increasingly more complex and more difficult to work with, a fact which itself must hinder progress. The need for a guide to the complete reptile and amphibian fauna of New Zealand is now greater than ever" (p. 5). However, Jewell's changes to the common and tag names make it difficult, even for experienced New Zealand herpetologists, to reconcile the names contained in the field guide with those contained in the herpetological literature and the New Zealand Threat Classification System Lists (Hitchmough et al. 2007). We therefore aim to provide information that will aid the accuracy of species identification when using Jewell's field guide. Since the majority of the changes relate to the two most diverse groups, the geckos and skinks, we outline some changes that have been made in these two groups, highlight several errors and inconsistencies, and provide updated information from recent publications.

Skinks

There are currently 33 described species and subspecies of extant native skink in New Zealand in two genera, *Cyclodina* and *Oligosoma*. Jewell lists 50 skink species (49 native, 1 introduced) and suggests that the skink fauna is likely to be split into more than two genera once a phylogeny has been published. Users of this field guide need to be aware of several recently published taxonomic revisions (including species descriptions) and phylogeographic studies on New Zealand skinks.

(1) The Sinbad skink (*Oligosoma* sp. 1 (p. 70) has been formally described as *O. pikitanga* (Bell & Patterson 2008).

(2) The slight skink *Cyclodina* sp. 1 (p. 110) has been described as *C. levidensa* (Chapple et al. 2008b).

(3) Hardy's skink *Cyclodina* sp. 2 (p. 111) has been described as *C. hardyi* (Chapple et al. 2008b).

(4) The Mokohinau skink *Cyclodina* sp. 5 (p. 117) has been described as *C. townsi*, with the common name Towns' skink, as this species is not restricted to the Mokohinau Islands (Chapple et al. 2008a).

(5) The recent publication of several molecular studies (Greaves et al. 2007, 2008; Hare et al. 2008; Liggins et al. 2008a,b; O'Neill et al. 2008) will require the revision of several of the species summaries (see Appendix).

(6) Greaves et al. (2007) produced a molecular phylogeny for the *O. chloronoton* (green skink)-*O. lineoocellatum* (spotted skink) species complex. Jewell recognises three regional forms (Southland, Stewart Island, Otago) within *O. chloronoton* (pp. 76–78), but none exactly match the genetic subclades (clades 3a–d) identified within this species, or even the two taxa recognised in Hitchmough et al. (2007) (*O. chloronoton* and *O. chloronoton* 'West Otago').

Jewell lists two taxa, previously part of *O. lineoocellatum*, as distinct species: the Lakes skink *Oligosoma* sp. 3 (p. 79; not previously recognised, but possibly might refer to *O. chloronoton* 'West Otago'), and the Mackenzie skink *Oligosoma* sp. 4 (p. 80; = clade 2c and *O. lineoocellatum* 'Mackenzie Basin'). Future morphological work may indeed confirm these as distinct species, but several more genetically divergent taxa in the remainder of the distribution are not separated (clade 1 = *O. lineoocellatum*: Nelson, Marlborough Sounds, North Island; clade 2a = *O. lineoocellatum* 'South Marlborough'; clade

2b = *O. lineoocellatum* 'Central Canterbury'), with only a short note in the species summary for *O. lineoocellatum* (p. 81) that they might represent distinct species. The species description and distribution map for *O. lineoocellatum* neglects a known population in Napier.

(7) Greaves et al. (2008) recovered a molecular phylogeny for the speckled skink (*O. infrapunctatum*) species complex. Four taxa previously assigned to *O. infrapunctatum* are recognised as distinct species by Jewell: Cobble skink *Oligosoma* sp. 9 (p. 94; not previously recognised), Crenulate skink *Oligosoma* sp. 10 (p. 96; = clade 2), Paparoa skink *Oligosoma* sp. 11 (p. 97), and Chesterfield skink *Oligosoma* sp. 12 (p. 98; = clade 3). The Crenulate and Chesterfield skinks are both genetically divergent and future morphological work might confirm their status as separate species. However, the most genetically divergent lineage within the *O. infrapunctatum* complex (clade 4 = *O. infrapunctatum* 'Southern North Island') is not considered as a separate species, although the possibility is mentioned on p. 95.
In contrast, Jewell lists the Paparoa skink, which is not genetically divergent, as a distinct taxon on the grounds that "the Paparoa skink is closely related to the speckled skink; it has evolved from within the speckled skink gene pool but has developed very distinctive traits" (p. 97). However, to us it is more plausible that it simply represents a morphologically aberrant population (i.e., anticryptic species; see Bickford et al. 2007) of *O. infrapunctatum*, as demonstrated by the molecular data, rather than a distinct species.

(8) The available genetic evidence does not support Jewell's recognition of several taxa as distinct species: (a) the Big Bay skink *Oligosoma* sp. 7 (p. 90); (b) the mahogany skink *Oligosoma* sp. 8 (p. 91); and (c) the Manawha skink *Cyclodina* sp. 4 (p. 114) from the Three Kings Islands, as it is not genetically divergent from *C. ornata* populations from the Northland region (see Chapple et al. 2008c). Similarly, there is no genetic support for the recognition of *C. pachysomaticum* (p. 116) as a separate species (Chapple et al. 2008a). It was synonymised under *C. oliveri* by Hardy (1977) and Chapple et al. (2008a). There is also a query as to whether the Barrier skink *Oligosoma* sp. 2 (p. 71) is sufficiently genetically divergent from the Sinbad skink (*O. pikitanga*, p. 70) to be considered a distinct taxon (c. 3% divergence compared to c. 7–10% among other recognised species in the same clade; see Bell & Patterson 2008). In addition, the Whirinaki skink *Oligosoma* sp. 14 (p. 107) is known only from video footage of a single individual, but its status is unknown because morphological and genetic analyses have yet to be conducted (it is listed as data deficient in Hitchmough et al. 2007).

(9) Jewell lists *Oligosoma suteri* (p. 68) under a new common name, the diving skink, when it has long been known as either the egg-laying skink or Suter's skink. This change in common name is inappropriate, because at least two other skink species (e.g., *O. smithi*, *O. acrinasum*) regularly dive into rock pools and seawater (see Miller 2007), whereas *O. suteri* is the only native egg-laying skink in New Zealand.

(10) The two subspecies of *O. nigriplantare*, *O. n. nigriplantare* (p. 101) and *O. n. polychroma* (pp. 92–93), are elevated to distinct species without explanation.

(11) The distribution map provided for the introduced rainbow skink (*Lampropholis delicata*; p. 121) neglects populations that have been established in the Waikato and Bay of Plenty regions since the 1980s, and in the Wanganui region for almost a decade (with populations in the process of establishing in other areas of the lower North Island).

Geckos

New Zealand currently has eight described species and one subspecies of *Naultinus* (green geckos), and 10 described species (nine extant, one extinct) of *Hoplodactylus* (grey-brown geckos). Here we provide some information to help readers update Jewell's species descriptions for geckos. In addition to these, the conservation status of 25 unnamed entities (24 *Hoplodactylus*, one *Naultinus*) has been assessed under the New Zealand Threat Classification System (threatened and data deficient entities are listed in Hitchmough et al. 2007). Jewell recognises these unnamed entities based on the unpublished thesis of Hitchmough (1997), and the subsequent DNA sequencing work of Hitchmough and colleagues, as well as several newly discovered morphologically distinct populations believed to represent distinct taxa. Although Rod Morris provides the photos, and Jewell the information for identification of these unnamed entities, many for the first time, the names used (including common and scientific names), and the very inadequate distribution maps, may introduce confusion, especially where subsequent research has not supported the formal taxonomic recognition of

certain entities. Here, we provide some information to help readers update Jewell's species summaries for geckos.

(1) *Hoplodactylus* 'Anatoki' is now considered to be conspecific with *Hoplodactylus* 'Mount Arthur' (Nielsen 2008). They are correctly combined as Kahurangi gecko (*Woodworthia* sp. 4) by Jewell.

(2) *Hoplodactylus* 'Cascades' Esperance population is now not considered to be taxonomically distinct from other populations of *Hoplodactylus* 'Cascades' (Nielsen 2008). Jewell correctly recognises only one entity.

(3) The Dansey's Pass gecko (*Woodworthia* sp. 8, p. 61) is listed as a distinct species, following Hitchmough (1997), but this distinction has not been supported by subsequent molecular work and it is not listed in Hitchmough et al. (2007).

(4) The pygmy gecko (*Woodworthia* sp. 1, p. 54) is listed as a separate species, but genetic analyses have not supported it as a distinct species (Neilsen 2008).

(5) Jewell correctly suggests that there is support for splitting *Hoplodactylus* into several genera (pp. 14–15), but he provides no explanation for the five gecko genera that he recognises (*Naultinus*, *Hoplodactylus*, *Woodworthia*, Genus A, Genus B) or the allocation of species among these genera. In particular, the proposed generic names are incorrect. The type species of the genus *Hoplodactylus* (Fitzinger 1843) is *Platydactylus duvaucelii* Duméril & Bibron 1836 by original description. The generic name *Hoplodactylus* should therefore apply to whichever genus *H. duvaucelii* (Duvaucel's gecko) is allocated to. However, Jewell has not adhered to this simple taxonomic rule (*H. duvaucelii* is incorrectly placed in *Woodworthia*; pp. 50–51).

Jewell is correct in avoiding the proposal of new formal specific names, but two names previously regarded as synonyms have been resurrected without explanation.

(1) Cope's 1868 name *Pentadactylus brunneus* (listed as *Woodworthia brunneus*; p. 53) was regarded by Kluge (1965) and Bauer (1990) as a synonym of *H. pacificus*, and the identity followed by the field guide has been proposed only in an unpublished thesis (Hitchmough 1997).

(2) Buller's (1881) *Naultinus sylvestris* (collected near Wanganui) is listed as Genus B: *silvestris* (p. 31). It is not clear what process was used to identify this taxon with genetically distinct forest gecko populations from Wellington and the Tararua Ranges.

The large number of undescribed species makes the alteration of common names, and removal of recognised tag names, a substantial problem for the geckos. In addition to the changes outlined above, the splitting of species formerly regarded as widespread into locally distributed entities will make it difficult for those not familiar with recent informally proposed changes to reconcile the species listed by Jewell with those currently recognised. For example, the widely distributed common gecko *H. maculatus* (known until 1977 as *H. pacificus*) is listed by Jewell as the Matua gecko *Woodworthia maculatus* (p. 52) and defined in a much more restricted sense.

The taxonomic status of the Cupola gecko *Hoplodactylus* 'Cupola' (Genus B: sp. 1, p. 34) is still undecided. The Cupola gecko has distinctive markings on the snout, but is otherwise not greatly different from the forest gecko *H. granulatus*. The limited evidence for its existence (a single small juvenile and a photograph of a second individual from the same area) does not include any material for genetic analysis. There is no evidence to link these specimens with forest gecko records from Marlborough and Canterbury and sloughed skins collected from these areas appear to be typical of those from *H. granulatus*. In the central North Island, *Hoplodactylus granulatus* and the undescribed species labelled as the Ngahere gecko (Genus B: *silvestris*; p. 31), are genetically distinct, but the location of the boundary between them is unknown, since they are difficult to diagnose morphologically. The distribution map should clearly state that it refers to unidentified forest gecko populations, not the Cupola gecko alone.

CONCLUSIONS

Jewell could have listed the reptiles and amphibians of New Zealand by including all the described species and subspecies, the unnamed entities listed in Hitchmough et al. (2007), and putative newly discovered species. We disagree with the naming system he adopted because it compromises what would otherwise have been an excellent, up-to-date field guide and a standard reference for all New Zealand (and other) herpetologists. For example, the potentially valuable discussion of regional endemism and distribution patterns (16 reptile regions, pp. 7–10) is compromised and will require revision.

Jewell states that "It is hoped that future revisions [of the field guide] will incorporate advances in

our knowledge about the species" (p. 13). If future revised editions address the issues that we have listed, then *A Photographic Guide to Reptiles and Amphibians of New Zealand* will become a worthy replacement for Gill & Whitaker (2001). Until then, for accurate species identifications, it will be necessary to use the field guide in conjunction with the information we provide here.

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Appendix Summary of recent taxonomic changes (excluding those specifically covered above) and phylogeographic publications with potential taxonomic implications for New Zealand skinks (adapted from the Department of Conservation North Island skink recovery group).

Cyclodina

Chapple et al. (2008c) presented phylogenies of the two clades of *Cyclodina*. They established that the *C. aenea* complex is more closely related to some *Oligosoma* than to the larger *Cyclodina* species. Information was also presented about geographic variation across the known ranges of each species. The Poor Knights Islands population of *C. ornata* was found to be deeply genetically divergent from the rest of *C. ornata*, and therefore a probable new undescribed species. Within the main group of *C. ornata* there are three clades which are moderately divergent: one from the Aupouri Peninsula and the Three Kings Islands, one from Auckland and the Hauraki Gulf, and one from the southern North Island.

Thus, the current species list for *Cyclodina* is:

Cyclodina aenea Girard, copper skink
Cyclodina alani (Robb), robust skink
Cyclodina hardyi Chapple, Patterson, Bell & Daugherty, Hardy's skink
Cyclodina levidensa Chapple, Patterson, Bell & Daugherty, slight skink
Cyclodina macgregori (Robb), McGregor's skink
Cyclodina oliveri (McCann), marbled skink—Poor Knights, Mercuries, Ohinau Islands, Aldermen
Cyclodina ornata (Gray), ornate skink
Cyclodina townsi Chapple, Patterson, Gleeson, Daugherty & Ritchie, Towns' skink—Mokohinaus, Great Barrier, Little Barrier, Hen and Chickens
Cyclodina whitakeri Hardy, Whitaker's skink
Cyclodina ornata 'Poor Knights'

Oligosoma

Greaves et al. (2007) examined geographic variation in the *O. lineoocellatum/O. chloronoton* complex. They found an initial 3-way split between (1) Nelson, Marlborough Sounds and North Island *O. lineoocellatum*, (2) South Marlborough and Canterbury *O. lineoocellatum*, and (3) Southland, Otago and Upper Waitaki Valley *O. chloronoton*. Within clade 1 there was lots of local population differentiation and a slightly deeper separation between the North Island and South Island populations (clade 1 was listed as *O. lineoocellatum* in Hitchmough et al. 2007). There was much deeper separation between three geographic groups within clade 2 (these were listed in Hitchmough et al. 2007 as *O*. aff. *lineoocellatum* 'Central Canterbury', *O*. aff. *lineoocellatum* 'Mackenzie Basin', and *O*. aff. *lineoocellatum* 'South Marlborough'). There are four subclades in *O. chloronoton*. The most divergent of these was listed in Hitchmough et al. (2007) as *O*. aff. *chloronoton* 'West Otago', and the rest were regarded as geographic variation within *O. chloronoton*. Greaves et al. (2007) found the three main clades to be extremely genetically divergent, with the possibility that new species will be described when a formal taxonomic revision is completed.

Greaves et al. (2008) investigated the phylogeny of the *O. infrapunctatum* complex. Deep genetic divergences were found within the species complex. Unlike the other geographically varied species and species complexes which have been studied, *O. infrapunctatum* did not show a simple pattern of geographic-based differences; instead the different clades mostly overlapped in distribution and most were found together on the West Coast of the South Island. Four major clades were identified, and two additional samples fell outside these clades. The most genetically divergent is clade 4, the southern North Island species (listed in Hitchmough et al. 2007). A single sample collected in Westport is related to, but substantially divergent from this clade. The other three major clades form a 3-way split. Clade 1 (which would be *O. infrapunctatum* sensu stricto as it includes the Stephens Island population, where the type specimen was collected) is found from Hokitika to Stephens Island. Distantly related to clade 1 is a sample from a high-altitude site on the Heaphy Track. Clade 2 includes North Island populations from Taumaranui to Whale Island and also samples from Granity and Hokitika. However, the North and South Island groups within this clade are quite deeply divergent from each other. Clade 3 includes the 'Chesterfield skink' and samples from the Alborn mine, although both are reasonably divergent from each other. In contrast, the Denniston and Paparoa samples which had appeared to be morphologically distinctive and had been suggested as likely new species were found to fall within clade 1.

Hare et al. (2008) examined geographic variation within *O. suteri*, *O. moco*, *O. smithi*, and *O. microlepis*. *O. suteri* had only extremely shallow genetic variation across its known range. *O. moco* had more genetic variation, with one

clade from the Hen and Chickens, one from the Poor Knights, Mokohinaus, Great and Little Barrier and Motukaramea Island (west of Coromandel), and one from Cuvier, the Mercuries, the Aldermen and Whenuakura. Divergence between these clades is moderate, and there is also a reasonable level of genetic divergence among islands within the major clades. *O. microlepis* was nested in the middle of *O. smithi*, dividing *O. smithi* into two genetically very distinct lineages. One is found at Spirits Bay and down the west coast of Northland to Muriwai, the other from Mt Camel south on the east coast. There is some regional structuring within the east coast species, with one genetic cluster from Mt Camel to Whangaruru Harbour and the Poor Knights, a second from Ocean Beach (Whangarei Heads) the Mokohinaus and Hen and Chickens, south to the Aldermen, and then more variation among the Bay of Plenty populations, and also the Sail Rock population.

Liggins et al. (2008a) reported that despite the morphological diversity among populations of *O. n. nigriplantare* in the Chathams there was only very shallow genetic divergence among them. The estimated time of divergence from *O. n. polychroma* was 5.8–7.3 myr. Elevation of the subspecies to full species was suggested but not formally proposed.

Liggins et al. (2008b) looked at geographic variation within *O. n. polychroma*. They found five deeply divergent clades. From south to north, clade 5 is found throughout Southland, Otago, the Mackenzie Basin and in coastal south Canterbury, and on Banks Peninsula and Kaitorete Spit. Clade 4 is found in inland north and central Canterbury and on the West Coast at Oneone River, clade 3 in south Marlborough, clade 2 in north-east Marlborough from The Brothers down to Waipapa Bay, and clade 1 on the West Coast from Greymouth north, in Nelson, the northwestern part of Marlborough, and the North Island. Clades 1 and 2 have a nuclear marker which is absent in the other three clades, adding to the inference that there is likely to be species-level diversity among these clades. Clade 1 includes the Grey Valley skink, previously regarded as a probable distinct species.

O'Neill et al. (2008) examined geographic variation in *O. zelandicum* and *O. maccanni*. *O. zelandicum* showed only very low-level genetic variation across its range. *O. maccanni* showed more substantial geographic structuring, although this was not interpreted as warranting taxonomic recognition. Clade 1 is represented by a single sample from Frankton, near Queenstown. Clade 2 is from western Otago and western Southland, from The Remarkables to just south of Lake Te Anau. Clade 3 is represented by a single sample from Lake Hawea in northwestern Otago. Clade 4 comprises samples from eastern Otago and eastern Southland, from the Ida Range south to the Hokonui Hills. Clade 5 incorporates samples from Lake Tekapo south to Lake Pukaki. Clade 6 is represented by two samples from the Banks Peninsula in Canterbury. Clade 7 encompasses two samples from south Canterbury, north of the Waitaki River. There is support for a close relationship between clade 1 and clade 2, with relatively little genetic divergence evident between these two. Although the subdivision of clades is generally north–south, there is a substantial east–west split in Otago and Southland.

More studies on *Oligosoma* spp. have been submitted for publication or are currently in preparation, therefore it is not possible at this stage to provide a current species list for *Oligosoma*.

Response

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INTRODUCTION

Preparing *A photographic guide to the reptiles and amphibians of New Zealand* (Jewell 2008) required covering a field in which a considerable number of taxa are undescribed, many populations are of uncertain status, and much research is still unpublished. And it required accommodating the often contrasting views and results from a number of different herpetologists. The book could not appease everyone's personal opinions on every single issue, but it is about the animals, not about taxonomy. The book is very accomodating of Chapple & Hitchmough's taxonomic proposals (in fact every single gecko species proposed by Hitchmough is included), but it sought a balanced approach by involving the views and results of other herpetologists too.

Where Chapple & Hitchmough (2009) have identified genuine errors or oversights on my part, I welcome this opportunity to correct them. I do not agree with their other comments, for reasons explained in detail below.

Points of agreement

Chapple & Hitchmough (2009) make one valid criticism concerning the naming of gecko genera. The type species of *Hoplodactylus* is *duvauceli*, not *pacificus*, so the name *Hoplodactylus* correctly

applies to the genus to which *duvauceli* belongs, and the one including *pacificus* is undescribed. They also identify what I consider to be minor omissions on three maps, i.e., the Cupola gecko, the spotted skink and the rainbow skink.

Points of disagreement

Names

Chapple & Hitchmough's opinion that: "There are existing common names for New Zealand's reptiles and amphibians, but Jewell states that 'the opportunity has been taken to suggest new and more appropriate common names that can be used indefinitely' (p. 14)" is quoted out of context. As can be seen on p. 14 of the book, that sentence clearly refers to tackling the issue of tag names, not to common names in general. Further, many undescribed species do not have names coined with vernacular usage in mind, but only temporary tag names (many of them based on inaccurate geographical summaries) coined by researchers who have not always consulted with colleagues about their choices.

I dropped the confusing tag name format, not the tag names themselves. I retained the identifying aspect of those names, so *Hoplodactylus* 'Southern Alps' becomes 'Southern Alps gecko'. Chapple & Hitchmough's discussion on skinks provides a good example of why the old tag name format can be confusing: they refer to "*O. chloronoton* and *O. chloronoton* 'West Otago'", without explaining whether these names refer to distinct species that somehow share the same scientific name, or to variants of the same species. Tag names must be accompanied by explanations if they are to be widely understandable, otherwise it is often impossible to determine what they refer to (e.g., Hitchmough et al. 2007 propose many new tag names with no supporting information or justification). The new field guide uses names in combination with photographs, distribution maps, descriptions and lists of other names by which the taxa are known, which together provide a clear basis for reconciling the names used there for these taxa with the names used in other publications. In addition, the Department of Conservation website contains a list comparing the names used by that organisation with the heading names used in the book (http://www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs).

Hitchmough (pers. comm. 2008) had previously indicated to me that he did not coin his own tag names with a direct conversion into common names in mind, and he agreed with me that some needed updating and that the new book would be a good opportunity to do this. For example, *Hoplodactylus* 'Mt Arthur' and *H.* 'Roys Peak' are species that are distributed far beyond those localities. It was with Hitchmough's concern in mind that I suggested some new names and sought his approval, which in most cases he gave. In the few cases where he suggested improvements these were adopted. I retained the old equivalents (e.g., 'Mt Arthur' gecko, 'Roys Peak' gecko) as an alternative name, specifically to avoid confusion.

I did not change the names of species; rather, I listed alternatives so that the preferences of as many people as possible could be accommodated. For the role of heading name to identify each photograph, I merely selected the one which I considered best reflected the animal. The existing names for two described species (*Naultinus punctatus* and *Oligosoma acrinasum*) are misleading, so I suggested new alternatives, with the existing names listed as alternatives, *not* omitted. Chapple & Hitchmough's comment that "not everyone will agree with his allocation of common names" illustrates precisely why a selection of names were given, and in their discussion they should have acknowledged that I listed alternatives rather than give the impression that I replaced existing names.

Among the examples of name changes quoted by Chapple & Hitchmough are the two lizard species found on the Open Bay Islands. For one, the existing name "Open Bay Islands gecko" (an undescribed gecko species) is not modified at all (p. 36), while for the other the old name of "Open Bay Islands skink" is retained as an alternative (p. 99). Whitaker & Lyall (2004) suggest that this species "is not likely to be a primary island endemic because the shallowness of the water between the mainland and the islands implies geologically recent isolation". For this reason the name "Open Bay Islands skink" is of questionable value; the alternative common name 'Taumaka skink' was employed as a heading name because it is both consistent with the scientific name, and somewhat ambiguous in its meaning, whereas "Open Bay Islands skink" is a clear informational statement that will require changing if a population is found on the mainland or in another island group.

For *O. suteri* I selected the existing alternative 'diving skink' as heading name (p. 68) because the common alternative, 'egg-laying skink' is potentially misleading. *O. suteri* is indeed the only native egg-laying skink, but most skink eggs encountered in

New Zealand are produced by another, much more common species, the introduced *Lampropholis delicata*. A number of other common names have also been used for this species, including Suter's skink and black shore skink. I disagree with the suggestion that, because several other species sometimes forage in water, the name 'diving skink' is inappropriate. Firstly, *O. suteri* displays a degree of aquatic activity matched only by *O. acrinasum*, a species which lives only at the other end of the country. Secondly, most of our lizards bear common names that could apply to numerous congeners, such as 'brown skink' for *O. zelandicum* and 'striped skink' for *O. striatum*.

Interpreting genetic data

Chapple & Hitchmough (2009) argue that genetic data do not support recognition of a number of undescribed species that were listed separately in the book. This objection raises deeper questions about the relative value of some forms of genetic information, describing phylogenetic history, versus others, such as genetically controlled functional characters relevant or even crucial to the process of speciation (and to taxonomic interpretation), including morphology, behaviour, mate recognition and genetic compatibility. For example, Chapple & Hitchmough state that genetic data do not support recognition of the Dansey's Pass gecko, yet field observations show that it overlaps in distribution (with little evidence of hybridisation) with its closest relative, the korero gecko (T. Jewell pers. obs.). Decisions about which populations warranted separate recognition in the book took into account all available lines of evidence, and in some cases functional characters such as morphology, and observations made along the geographical contact-zones between populations, were judged to be more informative about current relationships than were ancient phylogenetic histories.

The practice of relying upon phylogenetic data to justify the lumping of distinctive populations can be problematic. For example, Chapple et al. (2008) disregard Robb's (1975) species *Cyclodina pachysomaticum* by stating (p. 129) that "Our [molecular] data demonstrate that there is no support for the separation of [*C. oliveri*] from [*C. pachysomaticum*]", even though previously published morphological data (Hardy 1977) provides clear evidence for an evolutionary divergence between the two population groups. Likewise, they assert that molecular data "demonstrate" the Paparoa skink to be a "morphologically aberrant population" of *O. infrupunctatum* but offer no supporting data or explanation. It is important for Chapple & Hitchmough to explain their views on how simple genetic distance-values can demonstrate conspecificity among isolated, morphologically divergent populations, and until they do it is reasonable to continue giving consideration to other viewpoints.

Genetic data are often ambiguous when it comes to determining species status. For example, Hitchmough told me that Neilson's genetic data on the pygmy gecko (sent to me long after the book went to press) suggested that it may have been isolated from the most genetically similar sampled population of minimac gecko for up to 2.5 million years, and that this small subclade itself has been isolated from the main populations of minimac gecko for up to 5 million years, despite a present-day contact-zone. His assertion now that these data do not support recognition of the pygmy gecko is surprising because these data would appear to leave that possibility wide open. Further, a series of clear morphological differences involving multiple scale counts, colour pattern, proportions and size, sent to Hitchmough before he obtained any genetic data, are not mentioned. Even Hitchmough himself (1997), based solely on non-phylogenetic lines of evidence, has previously advocated the recognition of several species for which the genetic data he employed offered no support at all, e.g., the North Island species of *Naultinus*.

Minor details

Jewell (2008) is not intended to replace Gill & Whitaker (2001), which is still in print and could yet be revised. On the contrary, my book was intended to be a completely independent and less conservative alternative.

The statement "Since the majority of the changes [to names] relate to the two most diverse groups, the geckos and skinks..." clearly implies that I suggested name changes among groups other than lizards, which is untrue.

Chapple & Patterson (2007) is cited as a reference to the recent discovery of *O. taumakae* on Popotai Island; in fact this work states (p. 354) that *O. taumakae* "is known only from the island of Taumaka in the Open Bay Islands". The presence of this species on Popotai Island was not known until after Jewell 2008 went to press. With respect to the mahogany skink, I state (Jewell 2008, p. 91) that it "is another species of uncertain status". This is also true of the marbled skink *C. pachysomaticum* (p. 116).

The sentence "However, the most genetically divergent lineage within the *O. infrapunctatum*

complex (clade 4 = *O. infrapunctatum* 'Southern North Island') is not considered as a separate species, although the possibility is mentioned..." is hard to reconcile with the entry in my book which states on page 95 that this population "is definitely a separate species".

Chapple & Hitchmough state that my treatment of *Oligosoma chloronoton* is inconsistent with their own two treatments of it, including the genetic clades outlined by Greaves et al. (2008), but do not explain this view. Hitchmough et al. (2007) provide no supporting information about this species, such as distribution limits or morphological diagnosis, so their concept of it is unusable. However, my book fully accommodates the work of Greaves et al. (2008), differing only in that additional populations which they had not studied (such as the type population of *O. chloronoton*, at Te Anau) were included.

I can find no supporting evidence among modern literature for the idea that the lakes skink was formally included in *Oligosoma lineoocellatum* (sensu McCann 1955 or Hardy 1977). Jewell (2000) listed specimens as "a large and undescribed *Oligosoma* (which some authors have included in *O. chloronoton*.." and Jewell (2006) listed it as the "western form" of *O. chloronoton*; few other publications provide details such as specific distribution records or morphological summaries allowing populations of this species to be distinguished, and these all appear to refer it to *O. chloronoton* (e.g., Whitaker 1986). It appears to correspond to the more recent concept of "subclade 3A" used by Greaves et al. (2007) to describe some populations which they attribute to *O. chloronoton*. But matching it to Hitchmough et al.'s (2007) *Oligosoma chloronoton* 'western Otago' would be difficult, because no supporting information is provided and the implied distribution is inconsistent with the lakes skink, which also lives in Southland and Canterbury.

Chapple and Hitchmough's comment that the further potential species diversity in *O. lineoocellatum* is covered "with only a short note in the species summary for *O. lineoocellatum* (p. 81) that they might represent distinct species" seems unnecessary. The "short summary" in the book clearly points out the distribution range of each of the potential species, gives the phylogenetic basis for suspecting they may be distinct, and the reason for refraining from separating them in the book at this time.

The Whirinaki skink has indeed been subjected to morphological examination based on the available images of the sole known specimen, although the results are as yet unpublished. They were included in a detailed morphological comparison with similar-looking species by Tony Whitaker, who presented his results to a Department of Conservation skink recovery group meeting in 2007 and also circulated them to a number of herpetologists, including Hitchmough (A. H. Whitaker pers. comm. 2009).

Chapple and Hitchmough fear that "the splitting of species formerly regarded as widespread into locally distributed entities will make it difficult to reconcile the species listed by Jewell with those currently recognised". Taxonomic progress often requires old concepts to be overhauled, with the aim of providing a concept that is closer to reality, even if by implication the previous concept becomes redundant. In this sense the book follows the lead of Hitchmough et al. (2007) who employ extensive taxonomic splitting and extensive use of undescribed taxa. However, whereas Hitchmough et al. (2007) offered no means to reconcile their proposed taxonomic changes with actual specimens in the field or even with previously published taxonomic concepts, my book provides photographs, descriptions, an identification key and lists each name by which each taxon is commonly known, allowing each taxon to be compared with previous works.

Utilising published scientific names that have fallen into synonomy is a common practice. For example, Johns (2005) used the name *Metaglymma tersatum* despite its uncertain validity, but with justification provided; and Hitchmough himself resurrected *Hoplodactylus nebulosus* from recent formal synonomy (Thomas 1981) without any explanation (Daugherty et al. 1994). In the book I follow Hitchmough's (1997) use of *nebulosus* and *brunneus*, for which he provided clear justification. I also use *H. sylvestris* because this name is available for a species that is widely distributed in the lower North Island, but I do not link the name solely to Chapple and Hitchmough's geographically limited genetic sample.

I clearly state (p. 34) that all the populations lumped under the name Cupola gecko are unidentified. It says "a number of gecko populations representing Genus B are unidentified..." and it also specifically refers to the Cupola animals as "one such population...".

Chapple and Hitchmough conclude that "Jewell could have listed the reptiles and amphibians of New Zealand by including all the described species and subspecies, the unnamed entities listed in Hitchmough et al. (2007), and putative newly discovered

species". This is precisely what I did, but I also incorporated the findings of other herpetologists too such as Tony Whitaker (on the Rangitata and Whirinaki skinks), Trent Bell & Geoff Patterson (on the Barrier skink), and my own observations (including those on the manawha skink, *O. chloronoton* complex, jewelled, Dansey's Pass and pygmy geckos). Chapple and Hitchmough argue that "the potentially valuable discussion of regional endemism and distribution patterns (16 reptile regions, pp. 7–10) is compromised and will require revision" but give no explanation as to what way it is compromised.

CONCLUSION

I accept notification of several valid mistakes, and will address them in future revisions of the book. However, there is room for many shades of opinion on the wider issues raised by Chapple and Hitchmough. I aimed to accommodate a broad range of views, especially on names and taxonomic issues; Chapple and Hitchmough's reaction illustrates well the impossibility of writing a field guide that will satisfy everyone, when the subject is a group of animals for which data are limited and interpretations vary widely.

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