

# Southern African Gekkonids Diversity

Subjects: Biodiversity Conservation

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South Africa is recognised for its high reptile diversity and endemism, specifically among lizards. Phylogenetic diversity, endemism, and richness can have clear implications or raise important questions in a range of fields, and most urgently in conservation. Among squamate reptiles, these indices are very commonly associated with high temperatures and topographic heterogeneity. Indeed, mountainous biogeography has been a critical driver in the radiation of the family Gekkonidae within the subregion.

Keywords: CANAPE ; escarpment ; phylogenetic diversity ; phylogenetic endemism

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## 1. Introduction

Historical climatic and geological events and phylogenetic biogeography have played essential roles in driving the large-scale distribution or isolation of organisms <sup>[1][2]</sup>. Highlighting specific regions harbouring exceptional phylogenetic diversity, endemism, and richness can have clear and fundamental conservation implications <sup>[3]</sup> or raise important questions for investigating major evolutionary and biogeographic events <sup>[4]</sup> and ecological drivers <sup>[5][6]</sup>. Squamate reptiles are a diverse group, with approximately 9850 species distributed throughout the globe <sup>[7]</sup>. Correlations of species richness and diversity among reptiles are commonly associated with high temperatures and topographic heterogeneity <sup>[8][9][10]</sup>. Squamate reptiles make excellent models for investigating the evolutionary and biogeographical drivers of species richness and diversification due to their significant range in habitat utilisation, habitat specialisation, and limited dispersal abilities <sup>[11][12]</sup>.

South Africa is a megadiverse country with three global biodiversity hotspots: the Cape Floristic Region, the Maputaland-Pondoland-Albany Hotspot, and the Succulent Karoo. Regarding reptile distributions, compared to other African countries, South Africa has been relatively comprehensively sampled <sup>[13]</sup>. This area, including Lesotho and Eswatini, is also recognised for its high reptile diversity and endemism <sup>[14]</sup>. Mountainous biogeography has been a critical driver in the radiation of many reptiles within the subregion <sup>[15][16][17][18]</sup>. The complex topographic landscape has primarily been driven through two unrelated major geological events, namely the upliftment of the Great Escarpment and the Fold Mountains <sup>[19][20]</sup>.

## 2. Gekkonid Diversity

The Southern African gekkonids are one of the most diverse and highly endemic groups of reptiles within the region, consisting of 86 recognised species from 12 genera (**Figure 1**). Of these, ~75% species and 5 genera are thought to be endemic or near-endemic to the region <sup>[14][15]</sup>.

*Afroedura* Loveridge 1944 is a species-rich genus distributed throughout Southern Africa, extending northwards into Angola. Currently, there are 34 species <sup>[21]</sup>, with several awaiting description. The genus primarily comprises rock-dwelling, montane species, except for a few arboreal species (e.g., *Afroedura loveridgei* and *Afroedura marleyi*) <sup>[14][21][22]</sup>. Three major clades are present within *Afroedura*, predominantly along the isolates of the Great Escarpment, with some members occupying coastal plains or the Cape Fold Mountains <sup>[15]</sup>.

A monotypic genus, *Afrogecko* Bauer, Good & Branch, 1997, has a unique taxonomic past. Two subspecies, *Phyllodactylus porphyreus cronwrighti* and *Phyllodactylus porphyreus namaquensis*, neither of which is currently recognised <sup>[14]</sup>, require further investigation due to strong genetic differences, thus making *Afrogecko porphyreus* a species complex <sup>[23]</sup>. There remains a strong likelihood of cryptic taxa within the *Afrogecko porphyreus* complex <sup>[23]</sup>. No new material on the *P. p. namaquensis* has been collected to confirm its status. *Afrogecko porphyreus* is restricted to southwestern South Africa. It is predominantly rupicolous; however, some populations occupy vegetation within the coastal plains <sup>[22]</sup>.

The genus *Chondrodactylus* W. Peters, 1870 consists of large geckos, most of which are rupicolous, with some also displaying arboreal behaviour. Four species are present within South Africa [24], predominantly distributed inland of the Great Escarpment. A single member of the genus, *Chondrodactylus angulifer*, is a terrestrial burrower and has evolved accordingly [25][26].

The monotypic genus of leaf-toed geckos, *Cryptactites* Bauer et al., 1997 is a low-altitude coastal endemic. Its only species, *Cryptactites peringueyi*, is a small terrestrial and semi-arboreal gecko utilising coastal vegetation in a small range of the Eastern Cape province [27]. Its restricted range and poor phylogenetic diversity make this lineage the country's most range-restricted gecko genus.

Another group of small leaf-toed geckos are from the genus *Goggia* Bauer, Good & Branch, 1997. This near-endemic group consists of 10 species restricted to southern and northwestern South Africa. The genus consists of rupicolous and often mountainous genera, except for two species, *G. lineata* and *G. incognita*, which are found in shrub or fynbos in open vegetation types [22][28].

The most species-rich genus, *Hemidactylus* Oken, 1817, is widely distributed throughout the globe. Despite high diversification of *Hemidactylus* across the Afrotropic and subtropical regions, only a single species, *Hemidactylus mabouia*, is found within the borders of South Africa. The species is a generalist and occupies mountainous, inland, and coastal habitats [14][22]. They are successful invaders throughout the country and on a global level [12][14]. It is predominantly rupicolous; however, as with most rupicolous species within the region, it displays arboreal behaviour, and is, additionally, well-adapted to urban environments [22].

The genus *Homopholis* Boulenger, 1885 consists of four large-bodied, soft-skinned species. They are widely distributed, except for *Homopholis mulleri*, which is restricted to the northern extent of the Soutpansberg Mountains in Limpopo, South Africa.

Within the region, *Lygodactylus* Gray, 1864 consists of 11 species [22]. Many species have limited ranges, with several restricted to a single massif or mountaintop [14][22]. Radiation among *Lygodactylus* took place in two major clades, an Afromontane (greater Drakensberg) clade and a savanna-dwelling clade (except for a single montane species, *L. bernardi*, from Zimbabwe) [16]. *Lygodactylus capensis*, a widespread species from the savanna clade, is one of the most successful invaders within the country. The species has successful colonies throughout many western cities and towns far outside its natural range [29].

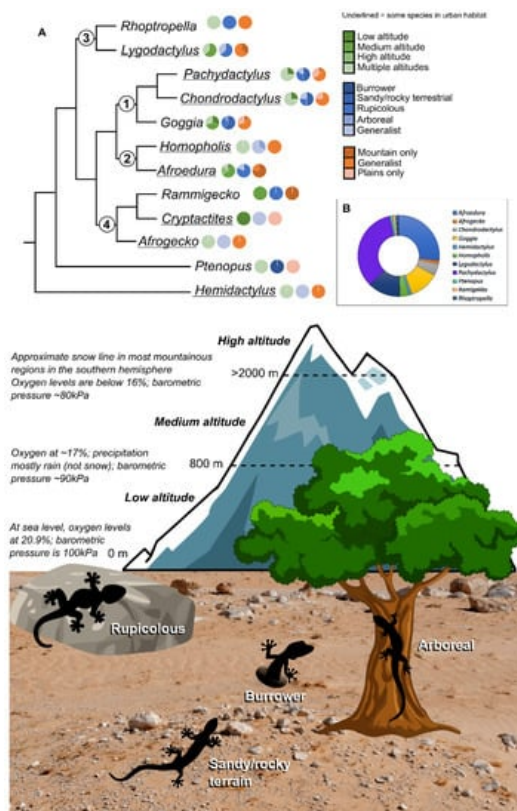
The most species-rich gekkonid genus within the region is that of *Pachydactylus* Wiegmann, 1834, which consists of 29 species. Radiation and endemism within the group were likely driven due to substrate specialisation in many species and historical vicariant events [30]. This group displays major differences in size [31], morphology [25][32], and geographical and environmental niches among species [28].

A single species of *Ptenopus* Gray, 1866 occurs within South Africa, with the remaining two species restricted to Namibia. The genus is known to predominantly occupy savanna, scrubland, and desert habitats [14][22]. They are commonly known to utilise characteristic burrows, often within loose soils, from where males call [33]. Intraspecific diversity among South Africa's only species, *Ptenopus garrulus*, is likely, with two subspecies currently recognised.

The genus *Ramigekko* Heinicke et al., 2014 consists of a single species, *Ramigekko swartbergensis*, which is a sizable rupicolous gekkonid restricted to the high mountain tops of the Klein and Groot Swartberg Mountains, within the Cape Fold mountain range [14][34][35][36]. The genus, which forms part of the circum-Indian Ocean leaf-toed geckos, was elevated from the now monotypic genus *Afrogecko* by Heinicke et al. [23]. Its closest living relative is the coastal endemic and monotypic genus, *Cryptactites*. The entire geographic range of the genus occurs in a predominantly inaccessible protected area, thus facing no major anthropogenic threats.

Another monotypic gecko, *Rhoptropella* Hewitt, 1937, a close relative of the Day Geckos—*Lygodactylus*, is another rupicolous genus. The small Namaqua Day Gecko—*Rhoptropella ocellata*, is restricted to mountain ranges in northwestern South Africa and southern Namibia [14]. This species is the only naturally-occurring diurnal gekkonid within this far-western arid region [22].

It is evident that there is exceptional diversity and endemism of gekkonids within the Southern African countries. Furthermore, with the group comprising several monotypic genera and genera with few species, it is essential that conservation measures are put in place to conserve phylogenetic diversity.



**Figure 1.** Representations of gekkonid genera within South Africa: **(A)** Simplified phylogenetic representation of the genera, constructed from the phylogeny produced in this study and from various published gekkonid phylogenies [15][37][38][39][40][41]. Numbers at the nodes indicate the Clade number. Pie charts at the tips indicate the number of species within the genus that inhabit various altitudes (green pie charts), the general habitat in which the species are found (biotopical preferences, blue pie charts), and the habitat specialisation of the species (orange pie charts). Genera that are underlined have species that enter into the urban environment. Information for the pie charts was obtained from the species accounts in the *IUCN Red List* (<https://www.iucnredlist.org/>; accessed on 17 December 2022). **(B)** Donut chart showing the number of species from each genus present in South Africa, Lesotho, and Eswatini. The illustration below details the biotopical preferences and altitudinal zone distinctions.

### 3. Conservation

A comprehensive assessment [42] estimating the extinction risk of reptiles found that ~21% are threatened with extinction. Conservation measures are often implicated in areas of high diversity and species richness [43][44], or specifically implemented for species of conservation concern (e.g., the establishment of the Mountain Zebra National Park (South Africa) in 1937, to protect the Mountain Zebra). However, phylogenetic diversity is often overlooked when assessing and planning conservation networks. Protected areas are critical for mitigating further biodiversity loss [45][46]. South Africa is a global leader in science-based conservation strategies [47][48][49][50]. The protected area network covers approximately 9% of South Africa's mainland surface area [51], and it is essential for conserving the diverse fauna and flora, maintaining livelihoods, economic development, and preserving many ecological services. Despite the sizable protected area network and protected area expansion plan [52], it is insufficient in protecting South Africa's threatened reptiles [53]. Fortunately, despite the high endemism and restricted distribution of many South African gekkonids [14], only a few taxa are listed under a threatened category in the *IUCN Red List*, these being *Afroedura multiporis* [54] and *Homopholis mulleri* [55], which are listed as Near Threatened, and a single Endangered species, *Lygodactylus methueni* [56].

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