

A high mountain lizard from Peru: The world's highest-altitude reptile

José Cerdeña¹, Jackie Farfán¹, Aarón J. Quiroz¹

¹ Universidad Nacional de San Agustín de Arequipa, Museo de Historia Natural, Av. Alcides Carrion s/n, Arequipa, Peru

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Corresponding author: Jose Cerdeña (cerdenajoseal@yahoo.es)

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Abstract

Life at high altitudes is particularly challenging for ectothermic animals like reptiles and involves the evolution of specialised adaptations to deal with low temperatures, hypoxia and intense UV radiation. As a result, only very few reptile taxa are able to survive above 5,000 m elevation and herpetological observations from these altitudes are exceedingly rare. We report here an exceptional observation of a lizard population (*Liolaemus* aff. *tacnae*; Reptilia, Squamata) from the high Andes of Peru. During an ascent of Chachani mountain (6,054 m, 16°11'S, 71°32'W), we observed and documented photographically this species living between 5,000 and 5,400 m above sea level. Following a review of literature, we show that this is the highest known record of a reptile species.

Key Words

Liolaemus, *alticolor-bibronii* group, *L. tacnae*, Chachani, Arequipa

Introduction

Adaptation to high elevation life in reptiles implicates different specialised anatomical and physiological strategies (Huey 1982; He et al. 2013; Reguera et al. 2014; Kouyoumdjian et al. 2019), which scientists are recently beginning to understand at the genetic level (Yang et al. 2014; Yang et al. 2015; Li et al. 2018). Factors identified as important in reptiles for allowing survival at the upper altitudinal limits relate to food availability and capacities for tolerating hypoxia and low temperatures (Navas 2002; Lu et al. 2018; Gangloff et al. 2019). Prior to this publication, the highest known altitude records for reptiles came from species in two lizard genera, *Phrynocephalus* (up to 5,300 m) from the Tibetan plateau and *Liolaemus* (up to 5,176 m) from the Andes (Zhao et al. 1999; Aparicio and Ocampo 2010; Li et al. 2017).

The South American genus *Liolaemus* constitutes one of the most diverse genera of reptiles known on Earth, with more than 270 species described to date (Abdala et al. 2020; Huamaní-Valderrama et al. 2020); it is distributed

from the Central Andes in Peru to Patagonia in Argentina (Pincheira-Donoso et al. 2008; Aguilar et al. 2013; Abdala et al. 2020). This includes the coastal regions of southern Peru and northern Chile (Valladares et al. 2004; Villegas-Paredes et al. 2020), as well as southern Brazil (Verrastro et al. 2003) and demonstrates a broad adaptive radiation of the genus in the region (Abdala et al. 2020). In Peru, 28 species in the genus *Liolaemus* have been described to date (Chaparro et al. 2020; Huamaní-Valderrama et al. 2020; Arapa-Aquino et al. 2021), although recent phylogenetic analyses have shown that this number is likely an underestimate, given the existence of several undescribed lineages or “candidate species” (Aguilar et al. 2017, 2018; Abdala et al. 2020; Huamaní-Valderrama et al. 2020).

Observations

On 18 October 2020, we ascended the summit of the Chachani mountain (6,054 m), located 20 km north

of Arequipa in south-western Peru. At approximately 09:00 hrs (local time) and at an elevation of 5,000 m, we observed from a distance of approximately five metres two small lizards moving and then hiding between large rocks, making further observations difficult. Later, during the same day, between 10:00 and 12:00 hrs (local time), a total of ten lizards of the same characteristics were observed between 5,000 and 5,400 m of elevation (Fig. 1A), where they were moving amongst the rocks. One individual was photographed at 5,400 m elevation (Fig. 1B), with coordinates 16°10'57"S, 71°32'02"W (Fig. 2). The habitat at the site is characterised by large rocks on the mountain slopes and the almost complete absence of vegetation (Fig. 1A), with only small herbaceous plants growing near the protected underside of rocks. The lizards were exclusively saxicolous, being observed moving only on rocky substrate.

Based on the pattern, colouration and size (approx. 11 cm total length) of the observed animals, we consider them to belong to the *alticolor-bibronii* group of the genus *Liolaemus*. We provisionally assign this population to *Liolaemus* aff. *tacnae*, because of its similarity to the *L. tacnae* which inhabits Chiguata (4,000 m elevation), approx. 30 km SE of Chachani mountain (Aguilar et al. 2013). However, a more detailed analysis is needed, including use of morphological and/or molecular evidence, to determine with more confidence the taxonomic status of this high mountain population.



Figure 1. The highest-altitude record for a reptile. **A.** View of the new record location, on the route of ascent from 5,000 m to the summit of Chachani mountain, south-western Peru. **B.** Adult specimen of *L. aff. tacnae* photographed at 5,400 m altitude (place of photography indicated with a red arrow in Fig. 1A).

The present observations represent the highest documented record for the genus *Liolaemus*, surpassing by more than 200 m elevation the previous record holders:

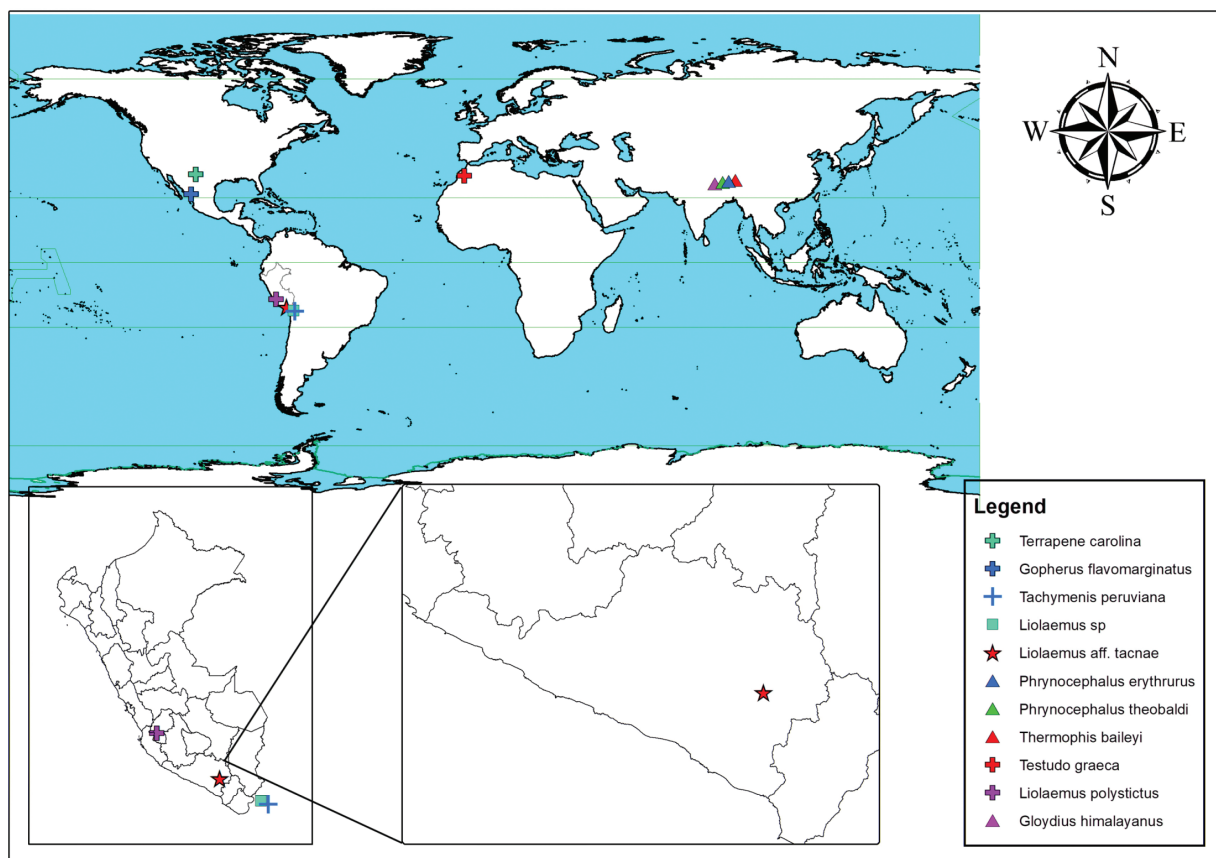


Figure 2. Map of the locations of highest altitude records of reptiles listed in Table 1.

Table 1. The world's highest altitude records for three major groups of terrestrial reptiles.

Group	Family	Specie	Altitude (m)	Region	Reference
Lizards	Liolaemidae	<i>Liolaemus</i> aff. <i>tacnae</i>	5000–5400	South America	Present study
	Agamidae	<i>Phrynocephalus erythrurus</i> Zugmayer, 1909	4500–5300	Asia	Zhao et al. 1999; Li et al. 2017
	Liolaemidae	<i>Liolaemus</i> sp.	5060–5176	South America	Aparicio and Ocampo 2010
	Agamidae	<i>Phrynocephalus theobaldi</i> Blyth, 1863	3600–5100	Asia	Zhao et al. 1999; Jin et al. 2017
	Liolaemidae	<i>Liolaemus polystictus</i> Laurent 1992	4043–5016	South America	Olivera and Aguilar 2020
Snakes	Colubridae	<i>Thermophis baileyi</i> Wall, 1907	3600–4900	Asia	Dorge et al. 2007
	Viperidae	<i>Gloydius himalayanus</i> (Gunther, 1864)	1500–4850	Asia	Whitaker and Captain 2004; Saikia et al. 2007
	Dipsadidae	<i>Tachymenis peruviana</i> Wiegmann, 1834	1800–4600	South America	Miranda et al. 2015; Gallardo et al. 2019
Turtles	Testudinidae	<i>Testudo graeca</i> Linnaeus, 1758	0–2090	North Africa	Anadón et al. 2012
	Testudinidae	<i>Gopherus flavomarginatus</i> Legler, 1959	1000–2000	North America	Becerra-López et al. 2017
	Emydidae	<i>Terrapene carolina</i> Linnaeus, 1758	300–1875	North America	Diggins et al. 2016

two Bolivian populations of *Liolaemus* reported between 5,060 and 5,176 m (Aparicio and Ocampo 2010). This population of *L.* aff. *tacnae* represents the reptile species that lives at the highest altitude on Earth (Table 1), exceeding by 100 m the record documented for the Asian species *Phrynocephalus erythrurus*, which inhabits the Tibetan plateau between 4,500 and 5,300 metres elevation (Zhao et al. 1999; Li et al. 2017).

The ongoing global warming trend has probably facilitated the survival of *L.* aff. *tacnae* at this record high site. The genus *Liolaemus* is well-adapted to a broad range of environments (Pincheira-Donoso et al. 2015) and climate change is expected to favour the expansion of species at their upper altitudinal limits (e.g. Wilson et al. 2005, but also see Parmesan 2006 for exceptions). This is particularly true for ectothermic animals, such as the lizards, whose vital functions are known to be directly dependent on ambient temperatures (Sinervo et al. 2018).

Conclusions

We hope that this report will encourage future research into the physiological mechanisms that allow these animals to live at such extremely high elevations through adaptations to low temperatures and low oxygen availability (e.g. Bennett and Ruben 1975; Lu et al. 2015; Cordero et al. 2017; Gangloff et al. 2019).

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