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An endemic new species of Andean lizard of the genus *Liolaemus* from southern Peru (Iguania: Liolaemidae) and its phylogenetic position

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***Abstract.*—Integrative evidence of several external morphological characters and molecular phylogenetic analyses of mitochondrial DNA (12S, cyt-*b*) are used to place a new species of Andean lizard of the genus *Liolaemus* (Iguania: Liolaemidae) in the *Liolaemus montanus* group and as sister group of the clade formed by *L. signifer*. The new species is characterized by a unique combination of morphometric characteristics, scalation, and color pattern. The *L. montanus* group now contains seventeen species in southern Peru, distributed along the eastern and western slopes of the Andes.**

Keywords. Andes, Apurimac, *Eulaemus*, Puna, reptile, systematics, taxonomy

Resumen.—Utilizamos evidencia integradora de varios caracteres morfológicos externos y análisis filogenéticos moleculares de ADN mitocondrial (12S, cyt-*b*) que ubican una nueva especie del género *Liolaemus* (Iguania: Liolaemidae) en el grupo de *Liolaemus montanus* y como grupo hermano del clado formado por *L. signifer*. La nueva especie se caracteriza por una combinación única de patrón morfométrico, escamación y color. El grupo *montanus* del género *Liolaemus* en Perú contiene diecisiete especies, distribuidas a lo largo de la vertiente oriental y occidental de los Andes en el sur del país.

Palabras clave. Andes, Apurímac, *Eulaemus*, Puna, reptiles, sistemática, taxonomía

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Introduction

Recent taxonomic and systematic studies of lizards of the genus *Liolaemus* in the traditional biogeographic regions of Peru, such as the coast and the Andes, have increased the diversity of Peruvian *Liolaemus* to 24 currently recognized species (Gutiérrez et al. 2018; Uetz et al. 2020). The genus *Liolaemus* was divided by Laurent (1983) in two main subgroups, *Liolaemus sensu stricto* (*L. chiliensis* group) and *Eulaemus* (Argentine group). The *L. alticolor-bibroni* group is placed within the *chiliensis* group (Aguilar et al. 2013; Barbour 1909; Gutiérrez et al. 2018; Lobo et al. 2007; Quinteros 2013; Shreve 1938, 1941), which includes seven Peruvian species (*L. alticolor*, *L. chavin*, *L. incaicus*, *L. pachacutec*, *L. tacnae*, *L. walkeri*, and *L. wari*). On the other hand, the Argentine group includes the most diverse *L. montanus* group (Abdala et al. 2019a), which has sixteen Peruvian species (*L. annectens*, *L. balagueri*, *L. chiribaya*, *L. etheridgei*, *L. evaristoi*, *L. insolitus*, *L. melanogaster*,

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L. nazca, *L. ortizi*, *L. poconchilensis*, *L. polystictus*, *L. robustus*, *L. signifer*, *L. thomasi*, *L. victormoralesii*, and *L. williamsi*), and the less diverse *L. boulengeri* group, represented only by one species in Peru (*L. ornatus*; Carrillo and Icochea 1995). All Peruvian *Liolaemus* species are distributed along the southern coast and the Andes (Abdala and Quinteros 2014; Abdala et al. 2019a; Aguilar et al. 2016; Gutiérrez et al. 2018). However, although studies on the *Liolaemus* of Peru have increased considerably in recent years, important knowledge gaps remain, and the diversity of the genus is underestimated (Abdala et al. 2019a; Aguilar-Puntriano et al. 2019).

In 2000, a series of expeditions began along the highlands of southern Peru, and several localities were surveyed in the departments of Apurimac, Arequipa, Ayacucho, Cusco, and Puno. Preliminary analyses reveal a much richer fauna of reptiles than previously known, including several new species that are in the process of description. During expeditions in the Puna areas of the Apurimac department, populations were found of a distinctive species of *Liolaemus* that belongs to the *L. montanus* group. These populations are characterized by the presence of a blade-like process of the tibia associated with hypertrophy of the muscle *tibialis anterior* and by having keeled dorsal scales. The new species is described here, and it is endemic to the southeast of the department Apurimac, in southern Peru.

Materials and Methods

Fieldwork procedures. Field work was conducted in 2011, 2012, 2016, and 2019 in the Dry Puna (3,740–4,615 m asl) of the central cordillera of the Andes in southern Peru, at the localities of Chila, Ccomerococha, Chequello, Choaquere, Ccosana, Huanacopampa, Huanquere, Kuchuacho, Ñahuinlla, Progreso, Pumamarca, and Punchayoc Ccasa, all in Apurimac department. Individuals of *Liolaemus qalaywa* **sp. nov.** were collected by hand and euthanized with a lethal dose of Halatal 1%. Tissue samples (muscle or liver) were taken and stored in microtubes (2 ml) containing 48% ethanol, and specimens were fixed over 24 h in 10% formalin and preserved in 80% ethanol. The examined material is listed in the Appendix.

Images and maps. Photographs of live specimens were taken using a digital camera (Canon EOS 70D). Close-up photographs of the holotype (preserved) were taken with a Stereo Microscope Optics Nikon SMZ25. The distribution map was elaborated in ArcMap 10.3, using coordinates previously used by Aguilar et al. (2016) and Gutiérrez et al. (2018). Type localities were taken from the original manuscripts of species descriptions. Coordinates of our records were taken with a GPS device (datum WGS84), Garmin Etrex 30.

Morphology. Qualitative and quantitative morphological characters of *Liolaemus* follow Abdala et al. (2019a,b). All bilateral characters were measured on the right side. Color in life was described based on field observations and photographs of captured specimens. Squamation was examined under a binocular microscope, and body measurements were taken with a precision caliper (±0.01 mm). The terminology of scale descriptions follows Abdala (2007), Abdala et al. (2019b), Etheridge (1993, 1995, 2000), and Laurent (1985). Color pattern terminology follows Abdala (2007), Abdala et al. (2019a), and Lobo and Espinoza (1999). Some specimens were dissected to determine sex and maturity; sex was determined using morphological characters such as snout-vent length, color and size of anal pores, and body color patterns. Museum acronyms are: Museo de Biodiversidad del Perú (MUBI); Museo de Historia Natural, Universidad Nacional de San Agustín, Arequipa, Perú (MUSA); and Fundación Miguel Lillo (FML).

DNA extraction, amplification, and sequencing. Corresponding voucher specimens are listed in Table 1. Total DNA was extracted from tissue samples at the Laboratory of Molecular Systematics of the Museo Nacional de Ciencias Naturales-CSIC (Madrid, Spain) using the Qiagen DNeasy extraction kit and protocol (Qiagen Inc., Hilden, Germany). Fragments of the mitochondrial small subunit rRNA gene (12S) and the mitochondrial cyt-*b* genes were amplified by polymerase chain reaction (PCR). Purified PCR products were sent to Macrogen Inc. (Seoul, Republic of Korea) for sequencing in both directions with the amplification primers. The primers 12SA4 L/12SB-H for 12S (Hillis et al. 1996) and Glu/CB3/F1/C2 were used for cyt-*b* (Morando et al. 2004). Raw sequence chromatographs for sequences generated in this study were edited using Sequencher 4.9 (Gene Codes Corporation 2009). Two new gene sequences of these loci were produced, with GenBank accession numbers for 12S of MT371370, and for cyt-*b* of MT366060–MT366062. Voucher information for new sequences is provided in Table 1.

Phylogenetic analyses. The sequences obtained in this study (Table 1) were compared with the homologous

Table 1. GenBank codes and voucher information of *Liolaemus* sequenced for this study. Localities and geographical coordinates are listed in the type material sections.

Species names	Voucher code	GenBank cyt-*b*	GenBank 12S
Liolaemus qalaywa **sp. nov.**	MUBI 12081	MT366061	MT371370
Liolaemus qalaywa **sp. nov.**	MUBI 12099	MT366062	
Liolaemus thomasi	MUBI 5925	MT366060	

sequences held in GenBank (Table 2) for the species of the *L. montanus* group that are registered for Peru and used in the latest studies by Aguilar et al. (2016) and Villegas-Paredes et al. (2020). This analysis used two samples of the new species (each one with 12S and cyt-*b*) and one sample from *L. ornatus* from the *L. boulengeri* group as "outgroup" (MUSM 31438), according to Aguilar et al. (2016, 2018) and Villegas-Paredes et al. (2020). The nucleotide sequences (79 cyt-*b*, 68 12S) were aligned using the MUSCLE algorithm (Edgar 2004) in MEGA version X (Kumar et al. 2018). Mitochondrial fragments (12S and cyt-*b*; 1303 nt, 79 individuals) were concatenated using the MESQUITE version 3.2 program (Maddison and Maddison 2017), and were run in Mr. Bayes v.3.2.2 (Ronquist and Huelsenbeck 2003). Bayesian Analyses were performed with the nucleotide evolution model GTR + G + I, for ten million generations each; an average standard deviation of the frequencies

Table 2. GenBank codes for sequences of *Liolaemus* lizards and the outgroup used in this study.

Species names	Voucher code	cyt-*b*	12S	Source
L. ornatus (outgroup)	MUSM 31438	KX826632	KX826732	Aguilar et al. 2016
L. annectens	BYU 50489	KX826616	KX826717	Aguilar et al. 2016
L. annectens	BYU 50486	KX826615		Aguilar et al. 2016
L. annectens	BYU 50491	KX826617	KX826718	Aguilar et al. 2016
L. annectens "Lampa"	MUSM 31433	KX826618	KX826719	Aguilar et al. 2016
L. balagueri	MUSA 5575	MK568539		Villegas-Paredes et al. 2020
L. balagueri	MUSA 5576	MK568538		Villegas-Paredes et al. 2020
L. etheridgei	BYU 50494	KX826620	KX826721	Aguilar et al. 2016
L. etheridgei	BYU 50495	KX826621	KX826722	Aguilar et al. 2016
L. etheridgei	BYU 50497	KX826622		Aguilar et al. 2016
L. etheridgei	MUSM 31493	KX826624	KX826724	Aguilar et al. 2016
L. etheridgei	BYU 50493	KX826619	KX826720	Aguilar et al. 2016
L. etheridgei	BYU 50499	KX826623	KX826723	Aguilar et al. 2016
L. etheridgei	MUSM 31494	KX826625	KX826725	Aguilar et al. 2016
L. insolitus	MUSM 31490	KX826627	KX826727	Aguilar et al. 2016
L. insolitus	BYU 50462	KX826626	KX826726	Aguilar et al. 2016
L. nazca (*L.* "Nazca")	BYU 50472	KX826673	KX826768	Aguilar et al. 2016
L. nazca (*L.* "Nazca")	BYU 50507	KX826674	KX826769	Aguilar et al. 2016
L. nazca (*L.* "Nazca")	BYU 50508	KX826675	KX826770	Aguilar et al. 2016
L. nazca (*L.* "Nazca")	MUSM 31523	KX826676	KX826771	Aguilar et al. 2016
L. nazca (*L.* "Nazca")	MUSM 31524	KX826677	KX826772	Aguilar et al. 2016
L. ortizi	MUSM 31513	KX826633	KX826733	Aguilar et al. 2016
L. ortizi	MUSM 31514	KX826634	KX826734	Aguilar et al. 2016
L. poconchilensis	MUSM 31545	KX826637	KX826736	Aguilar et al. 2016
L. poconchilensis	MUSM 31543	KX826635		Aguilar et al. 2016
L. poconchilensis	MUSM 31544	KX826636	KX826735	Aguilar et al. 2016
L. polystictus	MUSM 31451	KX826642	KX826740	Aguilar et al. 2016
L. polystictus	MUSM 31446	KX826641	KX826739	Aguilar et al. 2016
L. robustus	MUSM 31504	KX826646	KX826743	Aguilar et al. 2016
L. robustus	MUSM 31508	KX826648	KX826744	Aguilar et al. 2016
L. robustus	MUSM 31505	KX826647		Aguilar et al. 2016
L. robustus	BYU 50483	KX826643		Aguilar et al. 2016
L. thomasi	BYU 50469	KX826680	KX826775	Aguilar et al. 2016
L. thomasi	BYU 50466	KX826678	KX826773	Aguilar et al. 2016

Table 2 (continued). GenBank codes for sequences of *Liolaemus* lizards and the outgroup used in this study.

Species names	Voucher code	cyt-*b*	12S	Source
L. thomasi	MUSM 31516	KX826681	KX826776	Aguilar et al. 2016
L. thomasi	BYU 50467	KX826679	KX826774	Aguilar et al. 2016
L. signifer	MUSM 31443	KX826656	KX826752	Aguilar et al. 2016
L. signifer	MUSM 31434	KX826654	KX826750	Aguilar et al. 2016
L. signifer	BYU 50444	KX826652	KX826748	Aguilar et al. 2016
L. signifer	BYU 50357	KX826651	KX826747	Aguilar et al. 2016
L. signifer	BYU 50350	KX826649	KX826745	Aguilar et al. 2016
L. signifer	MUSM 31437	KX826655	KX826751	Aguilar et al. 2016
L. signifer	BYU 50355	KX826650	KX826746	Aguilar et al. 2016
L. signifer	MUSM 31447	KX826657	KX826753	Aguilar et al. 2016
L. signifer	MUSM 29110	KX826653	KX826749	Aguilar et al. 2016
L. melanogaster	BYU 50151	KX826628	KX826728	Aguilar et al. 2016
L. melanogaster	MUSM 31472	KX826630	KX826730	Aguilar et al. 2016
L. melanogaster	MUSM 31475	KX826631	KX826731	Aguilar et al. 2016
L. melanogaster	BYU 50154	KX826629	KX826729	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31371	KX826665	KX826757	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31374	KX826667	KX826762	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31373	KX826666	KX826758	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	BYU 50426	KX826661		Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31461	KX826668	KX826763	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	BYU 50430	KX826663	KX826760	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31462	KX826669	KX826764	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	BYU 50431	KX826664	KX826761	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	BYU 50428	KX826662	KX826759	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31464	KX826670	KX826765	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31465	KX826671	KX826766	Aguilar et al. 2016
L. victormoralesii (*L.* "AbraToccto")	MUSM 31468	KX826672	KX826767	Aguilar et al. 2016
L. williamsi	BYU 50463	KX826684	KX826778	Aguilar et al. 2016
L. williamsi	MUSM 31485	KX826687	KX826587	Aguilar et al. 2016
L. williamsi	BYU 50143	KX826682		Aguilar et al. 2016
L. williamsi	BYU 50464	KX826685	KX826779	Aguilar et al. 2016
L. williamsi	BYU 50144	KX826683	KX826777	Aguilar et al. 2016
L. williamsi	MUSM 31486	KX826688	KX826781	Aguilar et al. 2016
L. williamsi	BYU 50465	KX826686	KX826780	Aguilar et al. 2016
L. "AbraApacheta"	MUSM 31481	KX826660	KX826756	Aguilar et al. 2016
L. "AbraApacheta"	BYU 50145	KX826658	KX826754	Aguilar et al. 2016
L. "AbraApacheta"	BYU 50148	KX826659	KX826755	Aguilar et al. 2016
L. polystictus "Castrovirreyna"	MUSM 31454	KX826639	KX826738	Aguilar et al. 2016
L. polystictus "Castrovirreyna"	BYU 50630	KX826638	KX826737	Aguilar et al. 2016
L. polystictus "Castrovirreyna"	BYU 31455	KX826640	KX826570	Aguilar et al. 2016
L. robustus "MinaMartha"	BYU 50438	KX826644	KX826741	Aguilar et al. 2016
L. robustus "MinaMartha"	MUSM 31439	KX826645	KX826742	Aguilar et al. 2016

Fig. 1. Phylogenetic tree obtained using Bayesian Methods (BM)**.**

divided below 0.05 was obtained, trees were sampled every 1,000 generations from the Markov Chain Monte Carlo (MCMC) output and using four simultaneous chains (one cold and three hot) in each run. The convergences of the chains to the stationary distribution were confirmed using Tracer v1.7.1 (Rambaut et al. 2018) and the first 25% of generations that were not within the stationary distribution of the registration probabilities were conservatively discarded. The trees and subsequent probabilities were summarized using the "50% majority" consensus method (Huelsenbeck and Ronquist 2001; Wilcox et al. 2002). The resulting consensus tree was edited using FigTree v1.4.3 (Rambaut 2014).

Results and Discussion

Phylogenetic analyses. Our Bayesian phylogenetic analysis (Fig. 1) shows that the terminals MUBI 12081 and MUBI 12099 form a monophyletic subclade, sister of a terminal identified as *L. signifer sensu lato* (MUSM

29110) from Desaguadero, in Puno department, near the Bolivian border. The clade that contains these three terminals is deeply separated from its sister clade, which contains *L. signifer*, *L. annectens*, and *L. etheridgei.* Therefore, we consider that the new populations of *Liolaemus* studied herein represent a species different from those previously described for the *L. montanus* group. Likewise, in addition to *L. signifer*, *L. annectens* appears also to be paraphyletic, as the sample MUSM 31433 from Lampa (Puno department) identified as such is sister to a clade containing both *L. annectens* and *L. etheridgei*, a result already found by Aguilar et al. (2016).

Thus, the two divergent lineages represented by MUSM 29110 and MUSM 31433 might be two potential new species of the *L. montanus* group from the Andean highlands of southern Peru.

Taxonomy

Liolaemus qalaywa **sp. nov.**
(Figs. 2–3)

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Holotype. MUBI 13286, an adult male (Figs. 2–3) from Choaquere, District of Challhuahuacho, Province of Cotabambas, Department of Apurimac, Peru, (14°7’20.32”S, 72°13’29.27”W) at 3,740 m above sea level (m asl), collected on 15 December 2011, by L. Mamani and J.C. Chaparro.

Paratypes. Four adult males: MUBI 13265, from Ñahuinlla, District of Chorrillos, Province of Cotabambas, Department of Apurimac, Peru (13°57’20.64”S, 72°23’59.12”W) at 4,010 m asl, collected on 25 April 2016 by F.P. Condori; MUBI 12981, from Progreso, District of Progreso, Province of Grau, Department of Apurimac, Peru (14°5’16.07”S, 72°27’32.23”W) at 4,180 m asl, collected on 25 April 2016 by A.J. Quiroz; MUBI 17621, from Punchayoc Ccasa, District of Cotabambas, Province of Cotabambas, Department of Apurimac, Peru (13°47’23.55”S, 72°18’15.19”W) at 4,290 m asl, collected on 15 October 2019 by L. Mamani; MUBI 17622, from Ccosana, District of Haquira, Province of Cotabambas, Department of Apurimac, Peru (14°21’58.53”S, 72°20’40.10”W) at 4,615 m asl, collected on 16 October 2019, by L. Mamani. **One subadult male:** MUSA 5600, from Pumamarca, District of Challhuahuacho, Province of Cotabambas, Department of Apurimac, Peru (14°2’56.27”S, 72°19’46.10”W) at 4,615 m asl, collected on 10 December 2011 by A.J. Quiroz. **Nine adult females:** MUSA 5601 (MUBI 12080), MUBI 12081, and MUBI 12084, from Chila, District of Challhuahuacho, Province of Cotabambas, Department of Apurimac, Peru (14°7’5.65”S, 72°13’48.97”W) at 3,750 m asl, collected on 24 May 2012 by J.C. Chaparro; MUBI 12100, from Choaquere, District of Challhuahuacho, Province of Cotabambas, Department of Apurimac, Peru (14°7’20.32”S, 72°13’29.27”W) at 3,740 m asl, collected between 30 May and 6 June 2012 by J.C. Chaparro; MUBI 13260 (Fig. 3B,D,F,H) and MUBI 13264, from Ñahuinlla, District of Chorrillos, Province of Cotabambas, Department of Apurimac, Peru (13°57’20.64”S, 72°23’59.12”W) at 4,010 m asl, collected on 25 April 2016 by F.P. Condori; MUBI 13287 from Pumamarca, District of Challhuahuacho, Province of Cotabambas, Department of Apurimac, Peru (14°2’56.27”S, 72°19’46.10”W) at 4,615 m asl, collected on 10 December 2011 by L. Mamani; MUBI 15900 and MUBI 15903, from Ccomerococha, District of Coyurqui, Province of Cotabambas, Department of Apurimac, Peru (13°50’44.99”S, 72°21’24.14”W) at 4,310 m asl, collected on 13 July 2016 by A. Quiroz. **Thirteen immatures:** MUBI 12982–83, from Progreso, District of Progreso, Province of Grau, Department of Apurimac, Peru (14°5’16.07”S, 72°27’32.23”W) at 4,180 m asl, collected on 25 April 2016 by A.J. Quiroz; MUBI 12096–99 and MUBI 12101–04, from Choaquere, District of Challhuahuacho, Province of Cotabambas, Department of Apurimac, Peru (14°7’20.32”S, 72°13’29.27”W) at 3,740 m asl, collected on 30 May 2012 by J.C. Chaparro; MUBI 15901–02, from Ccomerococha, District of Coyurqui, Province of Cotabambas, Department of Apurimac, Peru (13°50’44.99”S, 72°21’24.14”W) at 4,310 m asl, collected on 13 July 2016 by A.J. Quiroz; MUBI 17623, from Ccosana, District of Haquira, Province of Cotabambas, Department of Apurimac, Peru (14°21’58.53”S, 72°20’40.10”W) at 4,615 m asl, collected on 16 October 2019 by L. Mamani.

Diagnosis. We assign *L. qalaywa* **sp. nov.** to the *L. montanus* group because it presents a blade-like process on the tibia, associated with the hypertrophy of the tibial muscle *tibialis anterior* (Abdala et al. 2019b; Etheridge 1995) and based on molecular phylogeny (Fig. 1). The species of the *L. montanus* group differ from those of the *L. boulengeri* group by the complete absence of patches of enlarged scales in the posterior part of the thigh (Abdala 2007). Compared to the species of the *L. montanus* group, *L. qalaywa* **sp. nov.** is a robust lizard differing by its larger size (max SVL = 96.06 mm) from *L. andinus*, *L. audituvelatus*, *L. balagueri*, *L. cazianiae*, *L. chiribaya*, *L. duellmani*, *L. eleodori*, *L. erguetae*, *L. erroneus*, *L. etheridgei*, *L. evaristoi*, *L. fabiani*, *L. famatinae*, *L. fittkaui*, *L. foxi*, *L. gracielae*, *L. griseus*, *L. hajeki*, *L. halonastes*, *L. huacahuasicus*, *L. insolitus*, *L. islugensis*, *L. molinai, L. montanus*, *L. multicolor*, *L. nazca*, *L. omorfi*, *L. orko*, *L. ortizi*, *L. pantherinus*, *L. poconchilensis*, *L. poecilochromus*, *L. porosus*, *L. pulcherrimus*, *L. reichei*, *L. robertoi*, *L. rosenmanni*, *L. ruibali, L. schmidti*, *L. stolzmanni*, *L. tajzara*, *L. thomasi*, *L. torresi*, *L. vallecurensis,* and *L. williamsi* (all with SVL 50–80 mm). The presence of imbricate dorsal scales with keels differentiates *L. qalaywa* **sp. nov.**

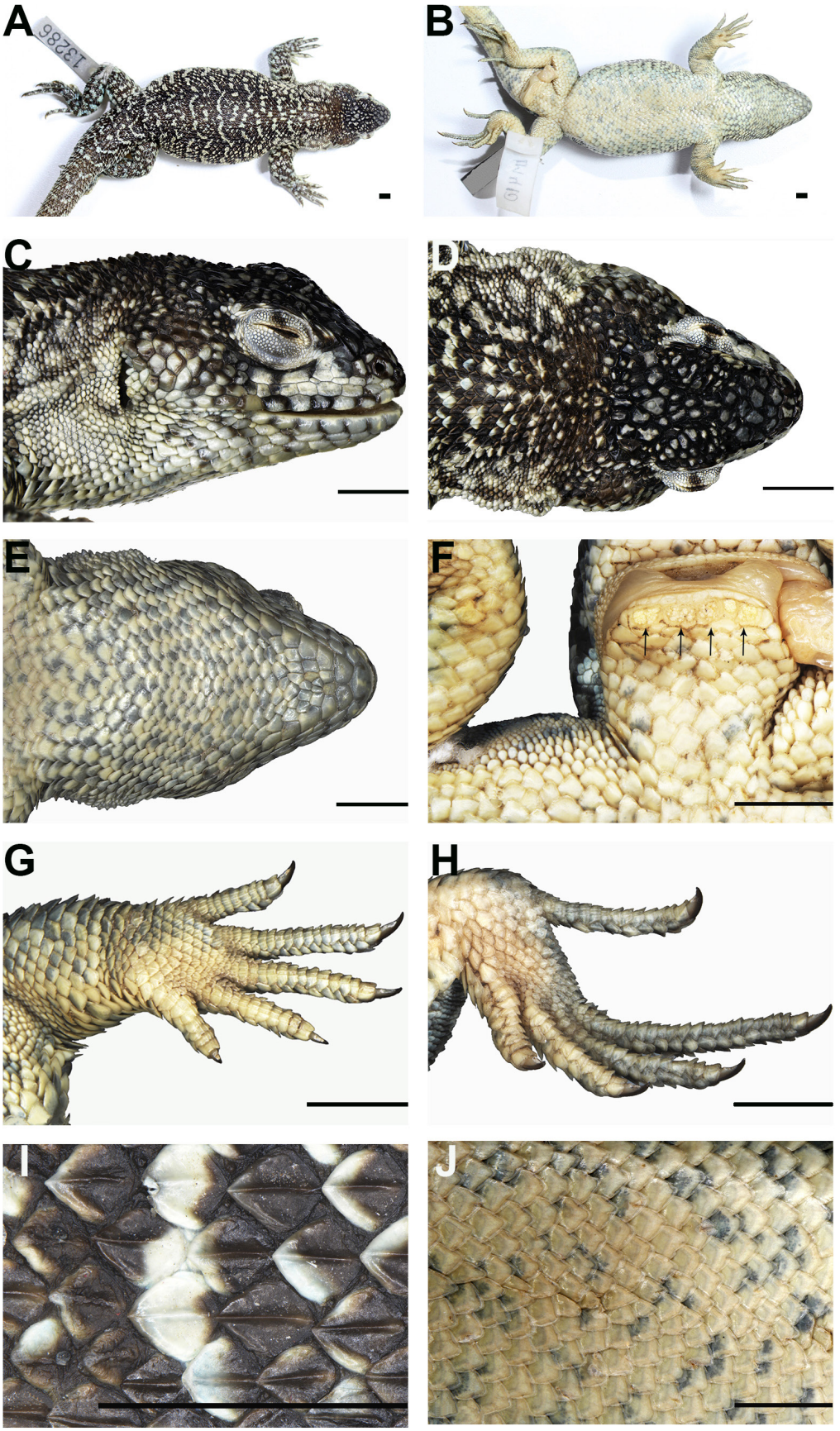

Fig. 2. Details of the holotype of *Liolaemus qalaywa* **sp. nov.** MUBI 13286 (SVL = 85.54 mm, Tail = 110 mm): (A) dorsal and (B) ventral views of body, (C) lateral, (D) dorsal, and (E) ventral views of head, (F) ventral view of precloacal pores, (G) ventral aspect of right hand, (H) ventral aspect of right foot, (I) keeled dorsal body scales, (J) ventral body scales. Scale = 5 mm.

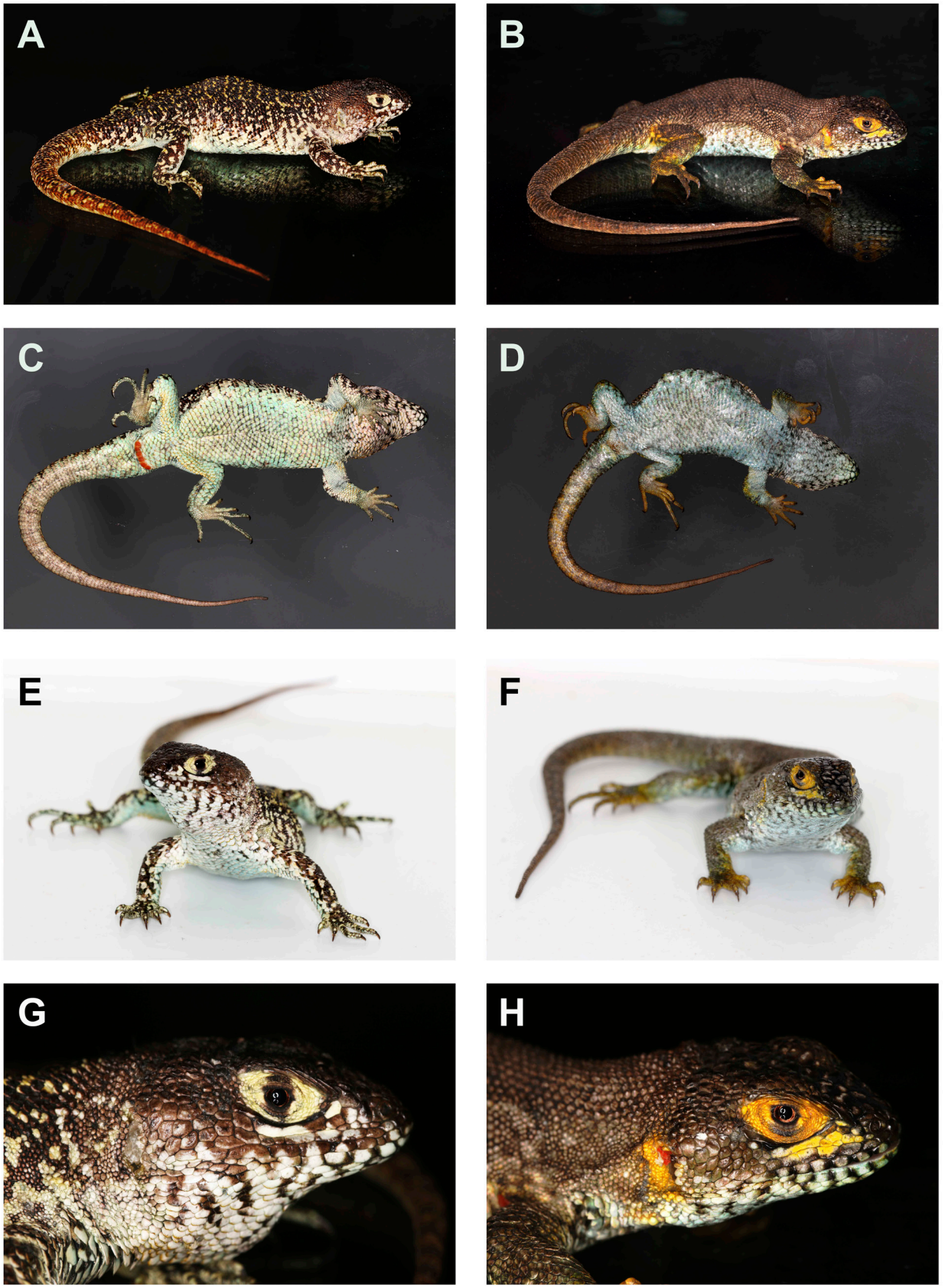

Fig. 3. (A, C, E, G) Adult male of *Liolaemus qalaywa* **sp. nov.** (unvouchered specimen; SVL = 91.9 mm, Tail = 121.1 mm); (B, D, F, H) Adult female of *Liolaemus qalaywa* **sp. nov.** (MUBI 13260 paratype; SVL = 85.53 mm, Tail = 110.78 mm). Both individuals are from Ñahuinlla, Department of Apurimac, 4,010 m asl.

from species with smooth juxtaposed or sub-imbricate scales such as *L. andinus*, *L. adituvelatus*, *L. balagueri*, *L. cazianiae*, *L. chiribaya*, *L. eleodori*, *L. erguetae*, *L. fabiani*, *L. foxi*, *L. gracielae*, *L. halonastes*, *L. insolitus*, *L. islugensis*, *L. jamesi*, *L. molinai*, *L. nigriceps*, *L. omorfi*, *L. patriciaiturrae*, *L. pleopholis*, *L. poconchilensis*, *L. poecilochromus*, *L. porosus*, *L. reichei*, *L. robertoi*, *L. robustus*, *L. rosenmanni*, *L. ruibali*, *L. schmidti*, *L. scrocchii*, *L. torresi*, *L. vallecurensis, L. victormoralesii*, and *L. vulcanus*.

The new species differs from *L. chiribaya*, *L. evaristoi*, *L. etheridgei*, *L. islugensis*, *L. insolitus*, *L. multicolor*, *L. omorfi*, *L. poconchilensis*, *L. pulcherrimus*, *L. robertoi*, *L. ruibali*, and *L. schmidti*, by the absence of sky blue or celeste scales on the sides and dorsum of the body and tail. The number of scales around midbody in *L. qalaywa* **sp. nov.** varies between 52 and 58 (mean = 54.6), which differentiates it from several species of the group with more than 65 scales, such as *L. andinus*, *L. annectens*, *L. adituvelatus, L. cazianiae*, *L. duellmani*, *L. eleodori*, *L. erguetae*, *L. forsteri*, *L. foxi*, *L. gracielae*, *L. halonastes*, *L. inti*, *L. molinai*, *L. multicolor*, *L. nigriceps*, *L. patriciaiturrae*, *L. pleopholis*, *L. poecilochromus*, *L. porosus*, *L. pulcherrimus*, *L. robertoi*, *L. rosenmanni*, *L. ruibali*, *L. schmidti*, *L. signifer,* and *L. vallecurensis*. The number of ventral scales between the mental scale and the border of the vent in *L. qalaywa* **sp. nov.** varies between 71 and 83 (mean = 75.7), and is lower than the number in the following species (with more than 90 ventral scales): *L. andinus*, *L. cazianiae*, *L. erguetae*, *L. foxi*, *L. gracielae*, *L. halonastes*, *L. inti*, *L. multicolor*, *L. nigriceps*, *L. pachecoi*, *L. patriciaiturrae*, *L. pleopholis*, *L. poecilochromus*, *L. porosus*, *L. robertoi*, *L. rosenmanni*, *L. torresi*, and *L. vallecurensis*; and higher than the number in the following species (with less than 70 ventral scales): *L. dorbignyi*, *L. fittkaui*, *L. melanogaster*, *L. polystictus*, and *L. thomasi*. Females of *L. qalaywa* **sp. nov.** exhibit precloacal pores in contrast to females of *L. andinus*, *L. adituvelatus*, *L. aymararum*, *L. balagueri*, *L. duellmani*, *L. fabiani*, *L. fittkaui*, *L. griseus*, *L. hajeki*, *L. islugensis*, *L. jamesi*, *L. melanogaster*, *L. polystictus*, *L. puritamensis*, *L. reichei, L. robertoi*, *L. rosenmanni*, *L. ruibali*, *L. signifer*, and *L. vallecurensis* (all lack precloacal pores). Additional measurements of morphometric characteristics in adult specimens are shown in Table 3.

The coloration patterns of males and females (especially the deep yellow and orange color around the eye), of the palpebral scales, and on the posterior inner edge of the auditory meatus in females are character states that have not been reported in *Liolaemus*. This exclusive coloration pattern in both sexes was seen in different individuals throughout the year. Therefore, they differ from all known species in the *L. montanus* group.

Description of the holotype. Adult male (MUBI 13286). SVL 85.54 mm. Head 1.08 times longer (20.24 mm) than wide (18.71 mm). Head height 15.9 mm. Neck width 20.5 mm. Eye diameter 4.67 mm. Interorbital distance 9.99 mm. Orbit-auditory meatus distance 8.71 mm. Auditory meatus 4.51 mm high, 1.53 mm wide. Orbit-commissure of mouth distance 7.35 mm. Internasal width 1.59 mm. Subocular scale length 5.3 mm. Trunk length 37.68 mm, width 28.7 mm. Tail length 110 mm. Femur length 16.03 mm, tibia 16.47 mm, and foot 22.8 mm. Humerus length 12.04 mm. Forearm length 10.91 mm. Hand length 14.11 mm. Pygal region length 7.67 mm, and cloacal region width 6.37 mm. Dorsal surface of head rough, with 13 scales, rostral 2.62 times longer (3.25 mm) than wide (1.24 mm). Mental larger (4.06 mm) than rostral, trapezoidal, surrounded by four scales. Nasal separated from rostral by two scales. Two internasals, longer than wide. Nasal surrounded by seven scales, separated from canthal by two scales. Six scales between frontal and rostral. Frontals divided into four scales. Interparietal larger than parietal, in contact with six scales. Preocular separated from lorilabials by one scale. Five superciliaries and 15 upper ciliaries scales. Three differential scales at anterior margin of auditory meatus. Six temporal scales. Five lorilabials in contact with subocular. Ten supralabials, which are not in contact with subocular. Seven supraoculars. Seven lorilabials. Six infralabials. Five chin shields, 4th pair separated by six scales. Fifty-six scales around half of body. Fifty-four triangular dorsal body scales, imbricated, with an evident keel; fore and hind limbs and tail with lamellar scales, imbricated and keeled. Seventy-one ventral scales, from the mental to the cloacal region, following the ventral midline of the body, laminar, imbricated. Thirty imbricated gulars, not keeled. Neck with longitudinal fold with 43 granular, not keeled scales, ear fold and antehumeral fold present. Gular fold absent. Eighteen subdigital lamellae on the 4th finger of the hand. Fourth toe with 23 subdigital lamellae with three keels, plantar scales with keels. Lamellar ventral tail, scales imbricated with a slight keel. Seven precloacal pores. Supernumerary pores present.

Coloration

Holotype coloration in preservative. Upper temporal area dark brown. Lower temporal region, supralabial, infralabial, lorilabial, and loreal scales white with dark edges. A transverse dark stain crossing the eye and the palpebral scales, the rest of it white. Lateral color of the neck white, back of the neck dark brown. Scales of body, limbs, and tail black with a white distal end. Irregular lines transverse to the body, white, with black edges, extending from one side of the body to the other. White spots on the back and sides of limbs, hands, tail, and scapular region. No vertebral line, dorsolateral bands, and ante-humeral arch. Sides of the body lighter below the lateral midline. Venter uniform, with white scales and black edges.

Color variation in life. *Liolaemus qalaywa* **sp. nov.**

Table 3. Measurements (in mm) of morphological characteristics in adult specimens of *Liolaemus qalaywa* **sp. nov.** * broken tail, ** regenerated tail.

Museum code	**MUBI 13286**	**MUSA 5600**	**MUBI 13287**	**MUBI 13264**	**MUBI 13260**	**MUBI 12100**	**MUBI 12084**	**MUBI 12081**	**MUBI 12080**
Stage of development	Adult	Subadult	Adult	Adult	Adult	Adult	Adult	Subadult	Subadult
Sex	**Male**	**Male**	**Female**	**Female**	**Female**	**Female**	**Female**	**Female**	**Female**
Type material	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype
Snout-vent length	85.54	79.25	79.35	77.23	85.53	79.43	79.75	68.51	74.78
Head length	20.24	18.86	18.09	16.85	19.34	17.23	18.20	16.04	16.89
Head width	18.71	13.35	17.32	15.46	16.71	15.45	15.75	14.10	15.66
Head height	15.90	10.64	12.36	12.54	12.10	12.50	11.64	9.68	11.03
Interorbital distance	9.99	8.25	9.16	8.90	9.30	8.99	9.06	8.50	8.99
Tail length	110.00	103.44	86.15 (*)	108.57	110.78	59.45 (**)	64.44 (**)	87.87	99.88
Cloacal opening width	12.76	9.56	10.74	10.64	11.64	9.69	13.14	10.77	11.49
Body width	28.70	17.42	26.85	24.41	34.34	29.34	30.28	22.06	26.18
Width of base of tail	37.68	33.67	40.20	38.28	37.34	42.76	36.52	28.87	32.61
Femur length	16.03	15.16	13.60	14.32	15.48	13.63	14.36	12.37	13.79
Tibia length	16.47	15.86	14.41	13.98	14.36	13.21	13.94	13.04	13.41
Foot length	22.80	19.12	19.67	19.24	20.17	18.62	19.03	18.00	19.65
Length of claw of the 4th toe	14.39	11.35	12.61	12.53	12.92	11.11	12.18	11.50	12.22
Humerus length	12.04	10.73	8.74	9.78	10.15	9.26	9.62	7.45	9.08
Humerus width	7.03	3.91	5.90	5.45	5.93	5.24	5.27	4.65	5.00
Radio length	10.91	9.93	9.45	9.68	9.54	8.63	8.99	8.76	8.84
Hand length	14.11	10.27	14.02	12.88	11.84	11.07	10.96	10.88	12.53
Tympanum height	4.51	3.57	3.91	3.85	4.16	3.64	3.72	3.36	3.18
Tympanum length	1.53	1.72	1.07	1.20	1.66	1.18	1.62	1.49	1.27
Neck width	20.50	13.10	17.40	15.62	17.44	15.11	17.43	14.46	18.00

shows evident sexual dimorphism. In males, head varies considerably from brown to black. The back of the head is generally black or dark gray, in most cases darker than the sides of the head. The temporal region is similar in color to the back, but with lighter shades and in some specimens with white, yellow, or light gray spots. The supralabial, infralabial, and part of the lorilabial scales are always lighter than the rest of the head, sometimes immaculate or tinted with darker colors. The subocular, preocular, postocular, and loreal scales in most specimens are faint yellow, white, or light gray with light blue shades. The eyelid scales are always conspicuous, faint yellow, as are the posterior internal scales of the auditory meatus. In some specimens, the atrial scales, or part of them, also have the same yellow color as the palpebral scales. The general color of the body varies between chestnut and dark gray. Most of the dorsal scales of the body have a posterior end lighter than the anterior end, with yellow being the predominant color. The design of the dorsal body color pattern is diffuse and variable. Some males do not have paravertebral or lateral spots, while others exhibit thin, irregular, dark-colored transverse lines with a light back trim, with black and yellow being the most common combination. These lines can thicken or have a sub-quadrangular shape in the paravertebral region, and in some specimens the yellow lines fuse in the vertebral region. In the scapular region, numerous circular spots are highlighted, small in size and white, yellow, or light gray in color; these spots may also be present on the sides of the body, including some that are irregular or oblong in shape. The limbs and tail have the same pattern as the body. On the back of the limbs there are small light-colored spots, mostly intense yellow. The sides of the fingers and toes are faint yellow or white. In the antehumeral, pygal, and femoral regions, yellow shades stand out. Most specimens are white ventrally, but several specimens have black or dark gray scale edges in the mental, gular, pectoral, and abdominal regions. Some specimens have gray ventral scales with a light blue or light gray distal end. The tail generally changes to a lighter color after the first third. In females the coloration pattern is totally different and, unlike most *Liolaemus* species, the females have a more lively and showy coloration than males. The main difference is in the deep yellow color of the palpebral scales, those of the internal auditory meatus, the sides of the fingers and toes, as well as the back of the thighs and arms. As in males, the back of the head is darker than the sides. The predominant color on the back is dark brown. Small spots or white scales are present on the frontal and interparietal regions.

The temporal region varies from brown to light gray. The supralabial, infralabial, and lorilabial scales are brown or light gray, with dark edges. The subocular, preocular, postocular, and loreal scales range from light gray to deep yellow. The color of the body varies from gray to brown and, like in the males, there are dark scales with a light distal end. The paravertebral spots are conspicuous and evident, generally black and diamond-shaped, which may be attached to a transverse black line that can extend to the vertebral zone and to the mediolateral line on the sides of the body. These paravertebral spots in some cases have a white anterior border. The sides of the body, humeral area, limbs, and tail have similar patterns as the males. Ventrally they are white or gray with some yellow undertones. In the gular and mental regions there may be dark spots and nuances, while on the belly some have iridescent scales that are greenish gray or bluish gray. The tail becomes darker distally.

Etymology. The specific epithet Qalaywa, refers to the Quechua word for the *Liolaemus* lizards from the high Peruvian Andes**.**

Distribution and natural history. All known specimens and observations of *L. qalaywa* **sp. nov.** come from the 12 localities of the type series, in the southeastern Department of Apurimac, Peru, at elevations between 3,740–4,615 m asl (Figs. 4–5). This species inhabits high Andean puna (Figs. 4–5). Within the geographical distribution of *L. qalaywa* **sp. nov.**, four vegetation units were determined: Wetlands, Puna Lawn, Grassland, and Bushes. The common floristic composition of each unit is as follows—Wetlands: *Distichia muscoides*, *Zameoscirpus muticus*, *Carex* sp., *Eleocharis albibracteata*, *Calamagrostis rigescens*, and *Oritrophium limnophyllum*; Puna Lawn: *Aciachne acicularis*, *Calamagrostis vicunarum*, *Paranephelius ovatus*, and *Trichophorum rigidum*; Grassland: *Jarava ichu*, *Festuca dolichophylla*, and *Calamagrostis* sp.; and Bushes: *Ribes* sp., *Gynoxis* sp., *Escallonia myrtylloides,* and *Berberis* sp. *Liolaemus qalaywa* **sp. nov.** inhabits all the vegetation units, but in wetlands the presence of lizards is restricted to the edges. During intensive field work in the study area, the presence of adult individuals was registered throughout the year; newborns (with presence of abdominal scar) appeared from November to March, and immatures were found from December to March. In December, some couples showing reproductive behavior were observed. The species presents a viviparous reproduction; an embryo was found inside the body of an adult female. Sympatric amphibian and reptile species include *Gastrotheca marsupiata*, *Pleurodema marmoratum*, *Telmatobius* cf. *jelskii*, *Liolaemus* aff. *incaicus,* and *Tachymenis peruviana*.

Individuals were registered and collected during the dry and wet seasons, in natural rocky areas (under rocks when hiding and on rocks when active). One of the authors spent 82 person-hours of search time, between 0815 and 1500 hrs distributed from 2013 to 2019; and the total captures (catch and release) were 249 individuals, 147 in the wet season and 102 in the dry season (97 males, 113 females, and 39 immatures). The average results of our records in areas with different degrees of impact per hour of effort varied: in natural areas without anthropic intervention, five individuals/hour of search were registered; in natural areas with little human impact, three; in agricultural areas (which include sectors with stones or rocky outcrops) 1.5; and in very impacted areas (including areas with removal of land and vegetation, like mining, roads, and buildings) the result was zero individuals per hour. In general, our observations show that *L. qalaywa* **sp. nov.** is abundant in sectors where the habitat remains intact, especially in areas with the presence of natural rock outcrops and scattered stones which serve as permanent or temporary shelters. However, in areas with the presence of agricultural, livestock, and open-pit mining activities, abundance tends to decrease, as the lizards maintain their populations at the perimeters of zones with anthropic activities.

Individuals of this species are capable of building their own burrows and taking advantage of the burrows of other animals, such as tarantulas and mice; in the same way, arachnids, insects, and small mammals use the lizard's shelters. Several individuals were observed thermoregulating on small and medium-sized stones, and on stony sandy substrate and grass-like vegetation, always near their shelters. The peak of activity was during 0900–1100 hrs.

The presence of ectoparasites of the family Trombiculidae was recorded throughout the year; however, the presence and density of ectoparasites seemed to be lower during December–March, increasing in number during April–November. The ectoparasites were found distributed in the mite pocket, tympanic duct, prefemoral region, inguinal pocket, and axillary pocket.

An adult male individual of *L. qalaywa* **sp. nov.** was registered eating a frog of the species *Pleurodema marmoratum*, when it was under a stone. Other individuals were seen consuming insect larvae.

Male-male interactions were observed, including aggressive behavior by back arching, followed by a mutual lateral presentation that ends with one lizard charging and biting the other, and the persecution from the winner to the loser. Also, when the lizards sense danger, such as when researchers try to capture them, they show back arching and opening of the mouth, producing an exhalation-like sound.

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Fig. 4. Habitat of *Liolaemus qalaywa* **sp. nov.** from localities in the Department of Apurimac: (A) Quequello; (B) Ñahuinlla; (C) Huanquere; (D) Choaquere; (E) Queuña; (F) Ccomerococha; (G) Huanacopampa.

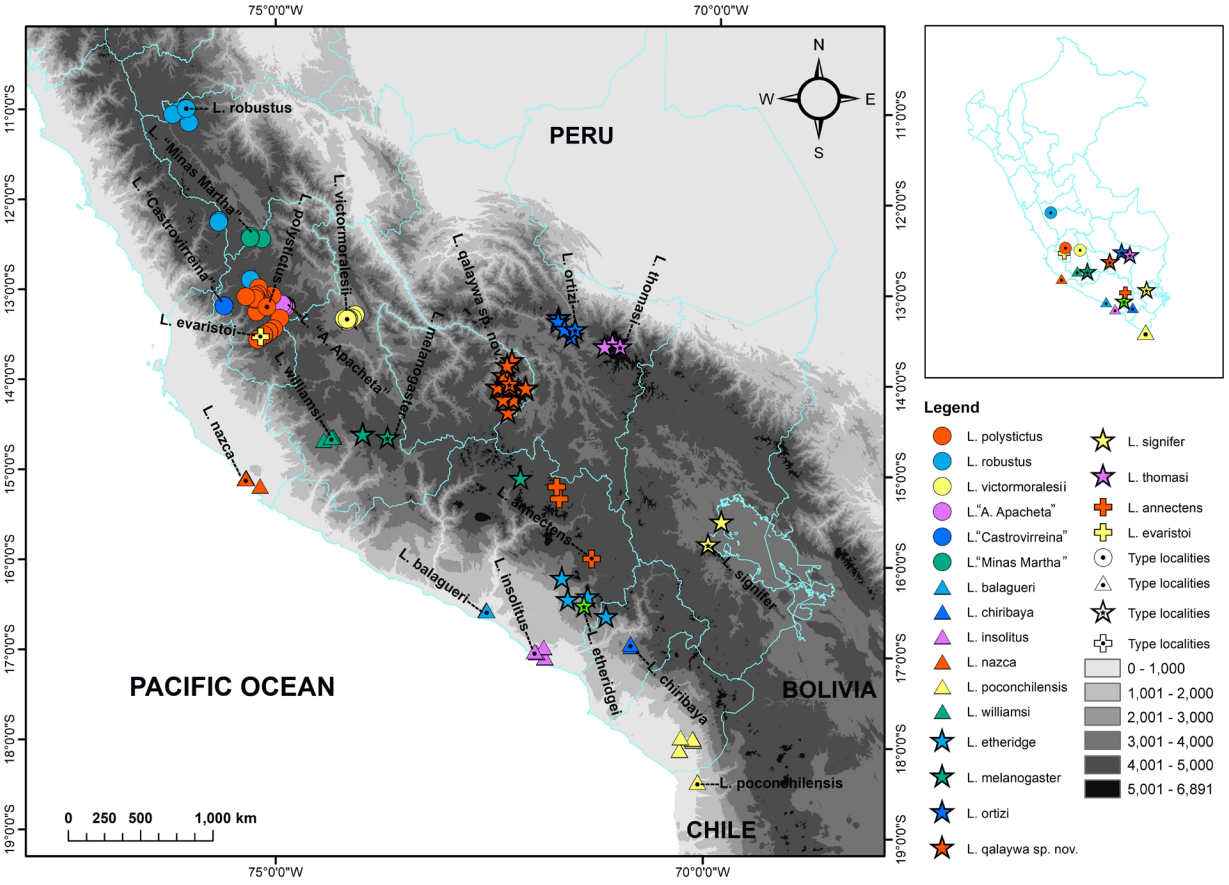

Fig. 5. Geographic distribution of 17 formally described species, and three candidate species of *Liolaemus*. Symbols with a black dot in the middle represent the type locality of each species. Species with quotation marks in names belong to the candidate species.

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Appendix. Specimens examined.

Liolaemus annectens (*n* = 15): **PERU. Arequipa:** Sumbay, MUSA 4114, 4265–66; Caylloma, MUSA 4344–4348, MUSA 1591–97.

Liolaemus etheridgei (*n* = 17): **PERU. Arequipa:** Cabrerías, Cayma, MUSA 501; Cerro Uyupampa, Sabandia, MUSA 549–54; Monte Ribereño de la Quebrada de Tilumpaya Chiguata. Pocsi, MUSA 1113–14, 1116, 1264–68, 1353; Anexo de Yura Viejo, Yura, MUSA 1229.

Liolaemus evaristoi (*n* = 16): **PERU. Huancavelica:** Los Libertadores, Pilpichaca, Huaytara, MUSA 2841 (holotype), 2781–85, 2840, 2842–45, MUBI 10474–78 (paratypes).

Liolaemus insolitus (*n* = 9): **PERU. Arequipa:** Quebrada Quialaque, Lomas de Challascapa, Mejia, Dean Valdivia Islay, MUSA 313–315, 320–324; Lomas de Mejia, Dean Valdivia Islay, MUSA 448.

Liolaemus melanogaster (*n* = 12): **PERU. Arequipa:** Laguna de Corococha, Orcopampa, MUSA 372–376; **Huancavelica:** Huancavelica, 1 km Southwest of Betania, MUSA 2762–2767. **Ayacucho:** 45 km East of Puquio, FML 2491 (paratype).

Liolaemus ortizi (*n* = 3): **PERU. Cusco:** Huacoto, MUSA-CSA 1432; Santa Barbara, MUSA 1443, 1511.

Liolaemus poconchilensis (*n* = 4): **PERU. Tacna:** MUSA 1428–29, MUSA 1638–39.

Liolaemus polystictus (*n* = 13): **PERU. Huancavelica:** Mountain close of Rumichaca, Pilpichaca, MUSA 1337–1338; Santa Inés, Castrovirreyna, MUSA 2448–2457; Santa Inés, FML 1683 (paratype).

Liolaemus robustus (*n* = 11): **PERU. Lima:** Surroundings of Huancaya, Reserva Paisajistica Nor Yauyos Cochas, MUSA 1693–1702; **Junín:** Junín, FML 1682 (paratype).

Liolaemus signifer (*n* = 12): **PERU. Puno**: Titicaca Lake, 3,840 m, FML 1434; Titicaca Lake, road to Puno, FML 1557; near Tirapata, MUSA 1415; Huancané, Comunidad Taurahuta, MUSA 1441–43; Huerta Huayara community, 3 km before Puno, MUSA 1483–87.

Liolaemus thomasi (*n* = 15): **PERU. Cusco:** After Mahuayani pass, MUSA 1398–1412; Pampacancha, Quispicanchi MUBI 5925.

Liolaemus williamsi (*n* = 15): **PERU. Ayacucho:** Surroundings of Pampa Galeras, MUSA 1519–1531, FML 1701 (paratype); Lucanas, Pampa Galeras, FML 13403 (paratype).