

Taxonomy and systematics

Resurrection and redescription of *Liolaemus reichei*, proposal of a neotype to stabilize its taxonomy

Resurrección y redescrición de Liolaemus reichei, propuesta de un neotipo para estabilizar su taxonomía

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Abstract

Liolaemus reichei was described by Werner and published by Otto Bürger in 1907 on the basis of 1 specimen captured in Iquique, Chile. The taxonomy of this species has been controversial, because it was originally placed in the genus *Phrynosaura* and was recently synonymized with *Liolaemus stolzmanni* based on a picture of the syntype of the latter species. We have identified a set of diagnostic characters that distinguish *L. reichei* from *L. stolzmanni*. Because there has been persistent confusion regarding the identity and the existence of the taxon described by Werner, we here resurrect, redescribe and designate a neotype of this species to stabilize the taxonomy of *Liolaemus reichei*. This work is based on specimens that were captured near Iquique, Chile, and is consistent with the original description.

Keywords: Atacama Desert; Chile; Lizards; Reptiles; Synonymy

Resumen

Liolaemus reichei fue descrito por Werner y publicado por Otto Bürger en 1907 en base a un espécimen colectado en Iquique, Chile. La taxonomía de esta especie ha sido controversial porque originalmente fue designada al género *Phrynosaura* y recientemente sinonimizado con *Liolaemus stolzmanni* basado en fotografías de un sintipo de esta última especie. Nosotros hemos identificado un set de caracteres diagnósticos que diferencian a *L. reichei* de *L. stolzmanni*. Debido a confusiones persistentes en la identidad y existencia del taxón descrito por Werner, aquí se ha resucitado, redescrito y designado un neotipo de esta especie para estabilizar la taxonomía de *Liolaemus reichei*. Este trabajo está basado en especímenes que fueron capturados en Iquique, Chile y es consistente con la descripción original.

Palabras claves: Desierto de Atacama; Chile; Lagartijas; Reptiles; Sinonimia

Introduction

Liolaemus reichei is an enigmatic species of the herpetological fauna from Chile. It was described by Werner, an Austrian naturalist who received 1 specimen from Otto Bürger. In 1907, Bürger translated the text from German into Spanish and mentioned that the specimen was captured by Karl Reiche in 1902 from Iquique, Chile. The species was described originally as a new genus and species, *Phrynosaura reichei*, characterized by external auditory meatus (no tympanum) distinct, broad head and short snout, smooth dorsal scales, rhomboidal, arranged like tiles on a roof. Dorsal head scales are the same size or larger than the dorsal body scales, smooth and convex. Two lateral nuchal skin folds reaching to the throat. Simple lateral teeth, coniform, with large canines, but no teeth on the palate; coniform tail, male with precloacal pores. Núñez and Yáñez (1983) cited as characteristic of genus *Phrynosaura* by the eyelids with a conspicuous comb, diameter of eye greater than length between anterior borders of eye and rostral, tail shorter than snout-vent length, head scales poorly differentiated, jaws isognathus, loreal region depressed and dorsal scales imbricate, smooth, with small accompanying scales.

L. reichei has been assigned to 3 different genera, *Phrynosaura* (Donoso-Barros, 1958, 1966, 1970; Laurent 1984, 1992; Müller, 1928; Núñez et al., 1998, 2003; Werner, 1907), *Ctenoblepharys* (Donoso-Barros, 1972; Núñez & Yáñez, 1983) and *Liolaemus* (Abdala & Quinteros, 2008; Abdala et al., 2008, 2009; Etheridge, 1995; Frost & Etheridge, 1989; Lobo et al., 2010; Pincheira-Donoso et al., 2008; Valladares, 2004; Valladares et al., 2002). Núñez et al. (1998) described the distribution of *Phrynosaura reichei*, where they mentioned various populations cited by Bürger (1907), Donoso-Barros (1958, 1969), Núñez and Yáñez (1983), and additional localities where it has been collected: Arica (near 18°20' S; 69°50' W), Hornitos (22°20' S; 70°30' W), Alto Guanillo (21°11' S; 70°06' W), Salar de Punta Negra (24°28' S; 68°54' W), Altos de la Quebrada Agua Colorada (23°10' S; 68°28' W), Diego de Almagro (26°23' S; 70°02' W) and Finca de Chañaral (near 26°23' S; 70°02' W). Some of these populations were described subsequently as a new species, for example *L. poconchilensis* from Arica (Valladares, 2004), *P. manueli* from Diego de Almagro and *P. torresi* from near Calama (Núñez et al., 2003).

The *Terra typica* of *L. reichei* is uncertain. In the original description it was assigned to “Iquique”, but Donoso-Barros (1972) assigned it to “Oasis de Pica”, an inland locality at ca. 1,200 m asl and nearly 120 km to the east of Iquique. In the herpetological collection of the Zoology Museum of the University of Concepción

a specimen was deposited and said to be the type of *L. reichei* (MZUC 011736, ex 5452 private collection of Donoso-Barros) collected near Antofagasta city on January, 1970. This specimen cannot be considered the type specimen because it was collected 406 km to southern of *terra typica*, and since there are no specimens of this species from Iquique deposited in any other collection, we consider the type specimen to be lost.

Recently, Langstroth (2011) synonymized *L. reichei* with *L. stolzmanni* (Steindachner, 1891) based on digital photographs of the syntypes of *L. stolzmanni* and 1 live specimen of said to be *L. reichei* from Oasis de Niebla de Alto Patache, 60 km south of the city of Iquique, Chile. According to this author, both the live animals and the preserved type series “show somewhat raised and outwardly projecting imbricate scales on the body and limbs, similar scale sizes and counts, as well as very similar patterns of darker pigmentation, such as a line extending from the loreal or preocular, through the orbit, and posteriorly through the temporal zone, 3 dark lines radiating from the orbit through the labials onto the maxilla, and paired series of rounded blackish spots on the dorsum, with intervening lighter zones”. Nevertheless, these similarities alone do not establish the synonymy of *L. reichei* with *L. stolzmanni*. Finally, Ruiz-de Gamboa and Ferrú (2013) named to 9 new populations of this species as *L. stolzmanni*.

In this work, we resurrect *Liolaemus reichei*, redescribed the external morphology, and since the type specimen is lost, we designate a neotype according to article 75 of the International Code of Zoological Nomenclature (ICZN, 1999), in order to contribute to stabilize the taxonomy of this species.

Material and methods

We studied the morphological characters traditionally used in *Liolaemus* taxonomy, including those of Laurent (1985), Cei (1986, 1993), Etheridge (1993, 1995, 2000), Lobo (2001), and Abdala (2002, 2003, 2007). We follow the terminology of Smith (1946) for descriptions of squamation and Frost (1992) for neck-fold terminology. Descriptions of body-color patterns follow Lobo and Espinoza (1999) and Abdala (2007).

Measurements and scale counts were recorded from specimens that were fixed in 10% formalin and preserved in 70% ethanol. Body and scale measurements were taken with digital calipers to the nearest 0.02 mm. When necessary, a binocular dissecting microscope (10-40X) was used to count and characterize scales. Where bilateral, scale counts and measurements data were taken from the right side of the lizards.

Specimens of *L. reichei* were collected 19.5 km

east of Iquique (20°14'23.5" S; 69°59'32" W), in sandy environments with rocks of different sizes, and the presence the *Tillandsia spp.* The climate is extremely dry, with the presence of small beetles and scorpions. Three adult lizards were collected in January 12, 2011, by Margarita Ruiz de Gamboa, Marcos Ferrú and Pablo Valladares, and deposited in the Colección Zoológica de Zonas Áridas y Andinas (CZZA 0300, 0301, 0302) at the University of Tarapacá, Chile. The neotype (CZZA 0300; Fig. 1) was compared with other species from the *L. montanus* group (*sensu* Etheridge, 1995; Schulte et al., 2000). Specimens were measured (Table 1) and compared with other “phrynosaurian” lizards from northern Chile (Table 2).



Figure 1. The neotype specimen collected in Tarapaca region, Chile.

Description

Reiche Lizard's, *Liolaemus reichei* (Bürger 1907) (Fig. 1)

Phrynosaura reichei Donoso-Barros 1958: 220, 1960: 65, 1964: 7, 1966: 345, 1969: 93, 1970: 102; Burt and Burt 1933: 39; Peters and Donoso-Barros 1970: 221; Laurent 1984: 359; Veloso and Navarro 1988: 513; Núñez and Jaksic 1992: 79; Núñez et al. 1998: 13.

Ctenoblepharis reichei (*sensu stricto*) Donoso-Barros 1972: 132; Cei 1979: 297.

Liolaemus reichei Etheridge 1995: 34, Etheridge and Espinoza 2000: 8, Valladares 2004: 43.

Liolaemus stolzmanni Langstroth 2011: 22, Ruiz de Gamboa and Ferrú 2013: 1067.

Diagnosis

Liolaemus reichei belongs to the *L. montanus* group (*sensu* Etheridge, 1995; Schulte et al., 2000). This species differs from all other species of the *L. montanus* group placed in the *L. boulengeri* subgroup by the absence of a patch of enlarged scales on the posterior thigh of the hind limb (Etheridge, 1995; Abdala, 2007). In relation of the remaining species in the *L. montanus* group, *L. reichei* differs from *L. annectens*, *L. caziana*, *L. chlorostictus*, *L. disjunctus*, *L. dorbignyi*, *L. duellmani*, *L. eleodori*, *L. erguetae*, *L. erroneus*, *L. etheridgei*, *L. fabiani*, *L. famatinae*, *L. filiorum*, *L. fittkai*, *L. forsteri*, *L. foxi*, *L. graciela*, *L. griseus*, *L. hajeki*, *L. halonastes*, *L. huacahuasicus*, *L. huayra*, *L. insolitus*, *L. inti*, *L. islugensis*, *L. jamesi*, *L. juanortizi*, *L. lopezi*, *L. melanogaster*, *L. montanus*, *L. multicolor*, *L. orientalis*, *L. orko*, *L. ortizi*, *L. pacheco*, *L. pantherinus*, *L. pleopholis*, *L. poecilochromus*, *L. polystictus*, *L. pulcherrimus*, *L. puritamensis*, *L. robertoi*, *L. robustus*, *L. ruibali*, *L. scrocchii*, *L. signifer*, *L. thomasi*, *L. vallecurensis*, *L. vulcanus*, and *L. williamsi* by a combination of characters: prominent ciliary scales;

Table 1

Morphological measurement of 3 specimens of *Liolaemus reichei*. Specimen CZZA-UTA 0300 corresponds to the neotype proposed in this paper. Measures are in mm. C = cut tail.

	CZZA 300	CZZA 301	CZZA 302
Sex	Female	Female	Male
Body length	50.82	50.78	41.55
Tail length	43.18	C	35.72
Head length	11.25	11.48	10
Head width	8.57	9.69	8.28
Forelimb length	22.11	24.38	21.37
Hindlimb length	33.35	31.59	30.12
Supralabials	9	9	9
Infralabials	6	8	6
Lorilabials	9	9	8
Scales around midbody	47	43	45
Scales of the body length	54	51	50
Precloacal pores	0	0	4

diameter of eye greater than length between anterior border of eye and rostral; external auditory meatus without projected scales on the anterior edge; jaws isognathus; smooth dorsal scales and juxtaposed; tail shorter than snout-vent length, which are absent in the species mentioned above. Of the species that have flat, smoothly overlapping scales, *L. reichei* differs from *L. andinus*, *L. audituvelatus*, *L. manueli*, *L. molinai*, *L. nigriceps*, *L. patricaiturrae*, *L.*

Table 2

Morphological measurement of *Liolaemus reichei* and 5 others “phrynosaurian” species. The order of the numbers corresponds to minimum, average (parenthesis) and maximum values found in the body measurements. Measures are in mm.

	<i>L. reichei</i> (n = 3)	<i>L. manueli</i> (n = 20)	<i>L. poconchilensis</i> (n = 4)	<i>L. torresi</i> (n = 8)	<i>L. audituvelatus</i> (n = 5)
Body length	41.5 (47.7) 50.8	42.7 (50.3) 60.7	47.17 (51.7) 53.83	53.8 (58.1) 64	50.7 (54.9) 58.3
Tail length	35.7 (39.5) 43.1	24 (46.2) 54	42.66 (47.2) 53.65	58.8 (57.4) 74	47.7 (48.9) 50.5
Head length	10 (10.9) 11.5	12.5	11.34 (13.1) 14.16	13 (13.6) 14.5	12.3 (12.9) 13.4
Head width	8.3 (8.5) 9.7	11.9	9.51 (10.9) 11.53	10.3 (11.02) 11.7	9.1 (9.8) 10.7
Forelimb length	21.4 (22.6) 24.4	22.5 (26.4) 28.8	22.2 (24.8) 27.5	26.3 (28.8) 30.5	26.7 (27.7) 30
Hindlimb length	30.1 (31.7) 33.4	31.5 (36.2) 49	31.15 (34.1) 32.62	38.6 (40.1) 42.2	34.5 (36.5) 38.1
Supralabials	9	10	12	10	12
Infralabials	6 (7) 8	7	8	7	7
Lorilabials	9	8	14	9	7 (8) 9
Scales around midbody	43 (45) 47	82	62	71	74
Scales of the body length	50 (52) 54	-	64	86	78 (83) 87
Precloacal pores	4	4	4	3	8

poconchilensis, *L. rosenmanni*, *L. schmidti*, and *L. torresi* because the latter have a higher number of scales around the body (over 70 scales). From *L. stolzmanni* it differs by having 9 supralabials scales (6 in *L. stolzmanni*), the interparietal and both parietal head scales large and well formed (relatively small, fragmented and irregular in *L. stolzmanni*), 8 lorilabials scales (5 in *L. stolzmanni*), and ventral side strongly variegated (white, immaculate or lightly variegated in *L. stolzmanni*) (Fig. 2), and by the presence of lateral nuchal skin folds well-developed and complex (lateral fold weak in *L. stolzmanni*).

Description of the neotype (adult female). Small lizard, slender body, limbs long and slender, triangular head and short, distinct from neck, widest across temporal region, 0.85 times wider (as measured across widest part of temporal region) than long (as measured from inferior apex of external auditory meatus to anterior surface of rostral). Snout short (as measured from tip of snout to anterior corner or orbit), 0.33 times head length, orbit (as measured along its greatest horizontal length) short, 0.31 times head length. Nasal region swollen, convex in profile, with a transverse indentation where the postrostral scale meets the nasal and internasal scales. Frontonasal region convex in profile. Rostral narrow, 2.7 times wider than high, bordered by 4 postrostrals. Nasals scales larger, separated from rostral and anterior supralabials by anterior lorilabials. Nostril oriented posterolaterally. Dorsal head scales larger,

differentiated, convex; 2 irregular prefrontals, 6 larger frontonasal scales arranged in a flower-shaped, a small medial scale surrounded by 5 large scales. All frontonasal scales irregular and convex. Two small postrostral scales. Two hexagonal internasals. Two medium scales between nasal and internasals, 1 small scale between postrostral and internasal, 2 small and irregular scales between nasal and frontonasal scales. Supraoculars large, 9 on each side, 4 irregular scale rows, mostly hexagonal, 4-5 in a horizontal line across widest part of supraocular region between superciliaries and frontals. Eleven and 12 scales form a well-defined circum orbital, somewhat irregular in size. Interparietal slightly smaller than adjacent parietal, hexagonal, bordered by 6 scales, with a distinct “eye” that correspond to pineal organ. Two elongated parietals, well-defined in their forms, posterior to interparietal. Six superciliaries larger, not keeled. Palpebrals small, convex and juxtaposed, 13 inner rectangular ciliaries, outer ciliaries of lower lid 11, triangular, sharply pointed distally; outer ciliaries of upper lid 12, third ciliary and 3 posterior ciliaries triangular, but not as strongly projecting as those of lower lid, those in middle of lid more nearly rectangular, not projecting. Preocular wider than subocular, pentagonal, preceded anteriorly by a large canthal, subocular elongated, about 8 times longer than high and postocular elongated but shorter than preocular and subocular. A single row of lorilabials, interrupted by subocular. Eight lorilabials.



Figure 2. Ventral side of 3 specimens of *Liolaemus reichei* strongly variegated. CZZA0300 corresponds to the neotype specimen.

Posterior to subocular, 6 scales smaller than lorilabials and supralabials, rounded and convex. Nine supralabials, equal in size to lorilabials. No supralabials in contact with subocular. One anterior and rectangular loreal, equal in size to second loreolabial, surrounded by preocular, lorilabials and 2 canthals. Temporals larger, convex, juxtaposed, 6 between postocular and anterior margin of ear. External auditory meatus large, rounded, 1.1 times higher than width, vertical diameter 0.56 times longitudinal diameter of orbit, bordered by irregular scales, 2 smaller anteriorly, 1 largest on the upper size and not differentiated from posterior temporals. Mental large 0.92 times as wide as rostral, bordered by 2 infralabials and 2 postmentals, not in contact with anterior sublabials. Infralabials 5, gulars medium size, smooth, rounded, convex, imbricate. Ventral scales triangular, similar in size to dorsal scales, imbricate and smooth. Posterior abdominal scales semirectangular. Scales of precloacal region similar to anterior ventrals, but wider than long. No precloacal pores. Dorsal scales of neck small, flat, slightly concave, triangular, nonoverlapping, no interstitial granules. Dorsal scales of body larger, rounded or semicircular. Some scales semitriangular, smooth and slightly imbricate. Lateral scales wider than long. Scales around midbody 47. Middorsal scales from occiput to point even with anterior margin of thigh 51. Lateral nuchal skin folds well-developed and complex. Two short folds,

one originating at superior and other at inferior margin of auditory meatus, converging posteriorly to form a V-shaped fold, continuing posteriorly as longitudinal neck fold, intercepted by oblique neck fold and antehumeral fold. Scales of lateral neck, flat or slightly concave, nonoverlapping. Immediately below the fold, triangular scales, imbricate and larger, similar to the gular scales. Limbs slender and long. Hindlimbs 0.7 times snout-vent length. Hindlimbs reaches the posterior edge of the eye. Scales are smooth and imbricate. Brachial scales triangular, about equal in size to dorsal body scales. Antebrachials tend to be rectangular. Elbow scales rounded, and wider than large. Preantebrachials flat, and semitriangular scales. Prefemorals small, convex, juxtaposed. Suprafemorals and postfemorals larger and triangular, smooth and imbricate. Supratibials and pretibials longer than wide, imbricate and rugous. Infratibials smooth, larger and triangular. Supracarpals smooth, rounded, imbricate, supratarsals smooth, triangular and imbricate. Infracarpals imbricate, somewhat projecting, mucronate. Infratarsals rounded, mucronate, imbricate; supradigitals imbricate, keeled and triangular, with distal margin slightly concave. Lateral digitals triangular, smooth, imbricate. Subdigital lamellae of fourth toe 18, claws long and slender. Tail short and thin, slightly thick at the base and somewhat depressed. The rest is slender and rounded distally. Tail

0.85 percent body length. Dorsal and lateral caudal scales tend to be rectangular, smooth and imbricate and wider than long on middle third of tail. Ventral caudal scales triangular on middle third of tail, but then are rectangular and strongly imbricate, longer than wider. Autotomic region with 12 scales on dorsal and lateral tail, and eight ventral scales.

The specimen designated as neotype has a dorsum color as light brown or gray color, similar to the sand on which they live. On the dorsal neck are 2 small black spots which are in parallel along to the dorsal body, where they get larger. Each side of the neck has black spots of the medium size, forming 2 parallel bands along the dorsum similar to those previously described. Scapular area shows a black spot subsequently followed a yellow spot, a pattern which is along the dorso-thoracic region; subsequently the yellow spots are located to the ventral side, which is repeated to the inguinal region. The black spots on median dorsal side area accompanied by small white spots. Along the dorsum 4 bands of rounded and black spots, the 2 most lateral with larger spots can be observed. On the tail there is a pattern of black spots laterally disposed, a pattern repeated to the end of tail. Ventrally there is a heavily variegated pattern, more intense on the lateral side and throat. Fore limbs without spots, hind limbs with white scales on the anterior thigh, accompanied with some black scales, without yellow spots.

Variation in morphological measures and scaling. It is based on 2 specimens, a male and a female collected from the same site of the neotype. Variation can be seen in table 1. In relation to the head, there is a low variation in the number and form of the scales, as rostral and postrostral (all with 2 scales), 9 supralabials, circum orbital well defined, large and no fragmented subocular, parietals large, pentagonal and well defined, number of scales between posterior edge of the eyes and ear edge (all with 7 scales), and large antehumeral folds. Difference was observed mainly in the form of interparietal, in both females they are hexagonal, while in the male it is pentagonal, in the latter there are small scales between the interparietal and postfrontals. Furthermore, there is variation in the number of infralabials, scales around and along the body. Variation is also observed in the number of internasals, which are fragmented in females. The juvenile male has only 2 parallel bands of the black spots on the dorsal zone, which are subsequently accompanied by yellow spots. In the middle of the body there are small white spots, which are found together with small black spots in the lumbar region. The tail has a spotted pattern similar to females. Forelimb with small white spots, and hindlimbs with black and white spots. Ventrally there is a heavily variegated pattern, similar to the females. The color of the neotype

in alcohol is dark gray in dorsum, and clear gray, with variegated form maintained.

Biology. The knowledge of this species is very poor. Apparently, its distribution is restricted to the Tillandsials formation (Pinto, 2005), found on the coastal dunes of Iquique, Chile. Ruiz-de Gamboa and Ferrú (2013) confirmed their distribution on 9 localities, all corresponding to “absolute desert” and “desert scrub”, but they did not make an analysis of inter-population variation. Their activity is crepuscular, and this species regulate its temperature at midday under rocks or Tillandsials. Reproductive phenology, as well as diet, is unknown. *Liolaemus reichei* is consumed sporadically by the fox *Lycalopex culpaeus* (Guzmán-Sandoval et al., 2007)

Discussion

In proposing the synonymy of *L. reichei* with *L. stolzmanni*, Langstroth (2011) described the similarity of a single specimen of *L. reichei*, but failed to point out their differences. Furthermore, the site of collection of his specimen was not provided, and his photograph of the specimen does not show a number of critical characters for a complete comparison.

From the original photographs of *L. stolzmanni* shown in Langstroth (2011), it is possible to distinguish the difference with *L. reichei* in number of supralabials, numbers of lorilabials, and the presence of lateral nuchal skin folds well-developed and complex. Interparietal and both parietal head scales large and well formed (Fig. 3A), and ventral side strongly variegated. However, it is not possible to see more details of external morphology, for example the rostral and postrostral scales and how these meet with the nasals and internasals scales. The scales of the frontonasal region, orientation of the nostril, dorsal head scales and circum orbital are poorly observed; superciliaries and outer ciliaries of the upper and lower lids are not distinguishable, subocular and the canthal is difficult to see. The scales around midbody are undistinguished and it is very difficult to count scales along the body. Carpal and tarsal scales are not clearly visible.

Langstroth (2011) considered appropriate to use the description of Donoso-Barros (1966) of *L. reichei* to compare with *L. stolzmanni*, for example with ventral scales, number of subocular or conical teeth, but Donoso-Barros did not have in hand specimens of *L. reichei sensu stricto* and the holotype mentioned there is from Antofagasta region (Herpetological Collection of the Zoology Museum of the University of Concepción, MZUC 011736, ex 5452 private collection of Donoso-Barros, specimens collected near Antofagasta city on January, 1970) here recognized as *L. cftorresi*. Donoso-Barros (1972) proposed the “Oasis

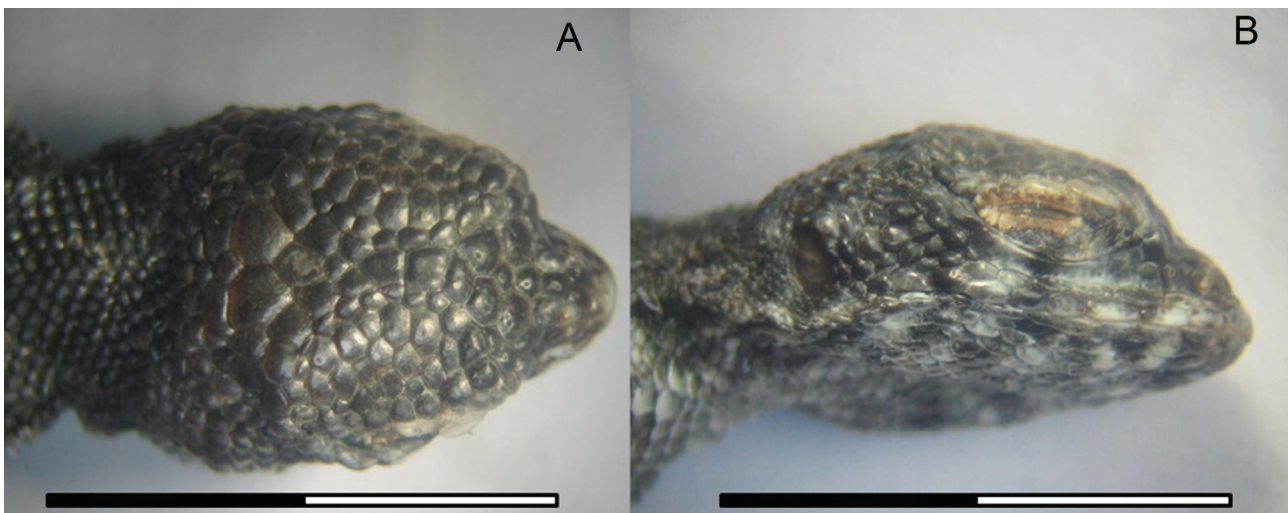


Figure 3. A) Dorsal and B) lateral head of neotype specimens of *Liolaemus reichei* of Colección Zoológica de Zonas Áridas y Andinas (CZZA 300) (scale bar represents 10 mm).

de Pica”, an inland locality at ca. 1,200 m and to the east of Iquique, the type locality of *L. reichei*.

Steindachner (1891) and Langstroth (2011) mentioned that the subocular is fragmented in 2 or 3 parts in *L. stolzmanni*, but our specimens of *L. reichei* have only 1 subocular, similar to the original “big sub-ocular” in Werner (1907) (Fig. 3B). Other similarities between *L. reichei* and its original description are the hindlimbs extend forward beyond the auditory meatus to the posterior edge of the eye. In view of these observations we propose a revalidation of *L. reichei*. With regard to *L. stolzmanni* it will be important to determine the true range. According to Langstroth (2011), no phrynosaurians species are known from high elevations (> 3,000 m), and it is not possible to determine the elevation for *L. stolzmanni* in “high Perú” or (“hoch Perú” as in the original description of Steindachner). However, it is possible to find *L. audituvelatus*, *L. torresi* and *L. manueli* in the prepuna ecoregion (~ 2,500 m) from Antofagasta and Atacama regions (Núñez & Veloso, 2001; Núñez & Yáñez, 1983; Valladares, 2011) and a similar elevation for *L. stolzmanni* in Tarapacá, Arica and Parinacota regions is possible, or even in the vicinity of Arequipa or Moquegua, southern Peru.

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