Short Note

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New data on *Abrawayaomys chebezi* (Rodentia, Cricetidae), a poorly known South American sylvan rodent

Abstract: *Abrawayaomys chebezi* is a spiny sigmodontine believed endemic to the Atlantic Forest of Misiones Province, Argentina. The available knowledge is largely restricted to the holotype, the only fully vouchered specimen. Here, we detail a second specimen, a subadult male obtained in the Parque Provincial Urugua-í (Misiones). The morphology of this animal confirms several diagnostic traits of *A. chebezi*, such as its smaller size relative to *Abrawayaomys ruschii*, the type species of the genus, and the simplified occlusal structure of its molars. New data on soft anatomy indicate that *chebezi* has a unilocular-hemiglandular stomach, no gall bladder, and a complex tridigitate penis with an external surface covered by rounded spines. A rich parasite assemblage including fleas and mites was recorded from this animal. A preliminary review of the alpha taxonomy of *Abrawayaomys* suggests the possible existence of three different species in the genus, one still unnamed.

Keywords: *Abrawayaomys ruschii*; Argentina; Atlantic Forest; Misiones; Sigmodontinae.

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The rich assemblage of mammals recorded in Misiones Province, Argentina, the southernmost expression of the Atlantic Interior Forest, includes some still poorly known forms. Within the cricetid rodents, a sylvan endemic representative of the genus *Abrawayaomys*, *Abrawayaomys chebezi* Pardiñas, Teta, and D'Elía, 2009, was recently described on the basis of a single trapped specimen (Pardiñas et al. 2009, 2015). Here, we add new information – including its soft anatomy and external parasites – retrieved from a second trapped animal. In addition, a preliminary review of observed variation among available specimens of the genus suggests the existence of three species, one as yet unnamed. Furthermore, we preliminarily refer the recent record for Paraná, Brazil, published as *Abrawayaomys ruschii* Cunha and Cruz, 1979 (Cerboncini et al. 2014), to *chebezi* based on morphology and measurements.

The new specimen of *Abrawayaomys chebezi* studied here was captured on September 29, 2012, in the Parque Provincial (PP, thereafter) Urugua-í, which is located on the basin of the arroyo Urugua-í in northeastern Misiones Province, Argentina. Framed between the Sierra de la Victoria on the north and the Sierra Morena to the south, the general landscape in this protected area includes low hills (<390 m) covered by forest with a rainfall about 2000 mm/year (Izquierdo and Srur, 2009). The specimen was trapped at the edge of a secondary forest fragment (25°49′43.47″S, 54°07′45.78″ W, 365 m), in a trap set on the ground. The gap, or forest edge, was part of an abandoned road about 600 m long and 6 m wide, with secondary growth ("capuera") of about 12 years old. In this gap, there is bunchgrass up to 1 m high, dominated by *Andropogon lateralis*, and intermixed with *Baccharis* sp. shrubs, with an overstory of saplings and young trees of pioneers such as *Trema michranta*, *Bastardiopsis densiflora*, *Solanum granulosum-leprosum*, and *Cecropia pachystachya*. The adjacent, undisturbed forest had emergent trees >25 m in height, of which *Tabebuia heptaphylla*, *Peltophorum dubium*, and *Ficus* cf. *luschnathiana* were dominant. Patches of bamboos (*Merostachys clausenii* and *Chusquea ramosissima*) were present in the shrub layer. Other cricetid rodents captured at the site where *A. chebezi* was

Q1: Please supply the binomial authority for each genus/species on first mention throughout

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collected included *Akodon montensis* Thomas, 1913, *Brucepattersonius* sp., *Euryoryzomys russatus* (Wagner, 1848), *Oligoryzomys nigripes* (Olfers, 1818), and *Sooretamys angouya* (G. Fischer, 1814).

The new specimen of *Abrawayaomys chebezi*, a subadult male with a scrotal testis, is housed in the Colección de Mamíferos del Centro Nacional Patagónico (CNP, Puerto Madryn, Chubut, Argentina) under the number CNP 3631 (field number CG 184, Carlos Galliari catalog). The animal was preserved with a somewhat damaged desiccated skin, cleaned skull, mandible, and partial postcranial skeleton, and stomach and penis in ethanol. Ectoparasites were collected in the field from the fur of the animal and prepared following conventional methods; their identification follow Hopkins and Rothschild (1966), Linardi and Guimarães (2000), and Furman (1972).

CNP 3631 shows the diagnostic traits of *Abrawayaomys chebezi*, reinforcing the uniqueness of the species on morphological grounds relative to the other known species in the genus, *Abrawayaomys ruschii*. Metrically, it is smaller than *A. ruschii*, particularly in dental measurements (Table 1). The animal is a long-tailed mouse; the body pelage is short and close with a clearly spiny texture; the general appearance is strongly agouti and hispid, darker at the midline and moderately countershaded below (Supplementary Figure 1); the ears are obvious and rounded; the vibrissae are long and thin (Supplementary Figure 2); and the tail is uniformly brown with conspicuous scales and has a short (ca. 6 mm) tuft of dark brown hairs in its tip (Supplementary Figure 2). The skull is robust, with a short and blunt rostrum, wide interorbital region, and a nearly square braincase; the nasals are narrow, parallel sided along the proximal half and shorter than the premaxillae; the interorbital region is relatively broad but "hourglass shaped", with rounded supraorbital margins; the coronal suture is wide and U shaped; the jugal is large, and the maxillary and squamosal processes of the zygoma are not in contact (Figure 1); the periotic is attached to the skull by a well-developed tegmen tympani, which overlaps the posterior suspensory process of the squamosal bone (Figure 1). A well-marked squamosal-alisphenoid groove anteriorly leads to a sphenofrontal foramen. A moderately thick alisphenoid strut crossing the foramen ovale accesorius is present; in addition, the anterior opening of the alisphenoid canal, partially bounded by a bony case, leads anteriorly to a small foramen on the alisphenoid-orbitosphenoid suture (Figure 1).

Both upper and lower incisors are impressive structures for their robustness and size (Supplementary Figure 3). The molar occlusal morphology of CNP 3631 fits well with the general pattern previously described for the holotype of the species (Pardiñas et al. 2009). Molars are brachyodont and have the main cusps disposed in alternate pattern, particularly evident in the lower molars (Figure 2). The M1 has a procingulum displaced to the labial side with an obvious anteromedian flexus. The mesoloph is fused to a paralophule, to form – together with the paracone – a large functional surface in the middle of the molar. The M3 is very small. Lower molars are characterized by a general simplification of occlusal morphology, including a transversally compressed procingulum without an anteromedian flexid, absence of mesolophids, and marked distoflexids (*sensu* Hershkovitz 1993).

The manus and pes morphology of *Abrawayaomys chebezi* can be surmised from the fresh condition of the new specimen reported here (Figure 3). The manus are dorsally covered by whitish hair; a pinkish tone of the underlying skin color is evident; ungual tufts extending beyond each claw are present; manual pads are smooth structures although well defined on the non-squamated pink plantar surface; interdigital pads 1 and 3 are subequal in size, and interdigital pad 2 is clearly smaller and placed at the base of an anatomical squared structure produced by the junction – an incipient syndactylous condition similar to that described by Hershkovitz (1990: 24) for *Akodon sanctipaulensis* – of manal DIII and DIV, which are nearly equal in length; manal DII and DV are subequal and DII is slightly longer; claws are short (~2 mm), curved, and narrow; and manal DI is very small and has a translucent claw. The pedes are somewhat darker above, long and narrow, with five large digits distally appearing bicolored due to the abundance and silvery color of the ungual tufts; the plantar surface is naked and covered with squamae (contrary to the smooth surface of the holotype of *chebezi*, a possible artifact due to the dry nature of this specimen); DII and DIV are subequal, and DIII is slightly longer than the previous ones; DV reaches the middle of the second phalanx of DIV; DI (hallux) is short, level with the middle portion of the second interdigital pad and has a claw; and pedal claws are short and ungual tufts surpass the claws in length (Figure 3). Four ovate interdigital pads are present; the hypothenar is large and rounded; and the thenar is narrow.

The stomach of *Abrawayaomys chebezi* is unilocular-hemiglandular, the most common pattern found in sigmodontines (Carleton 1973) and the same condition reported for *Abrawayaomys ruschii* (Finotti et al. 2003). Within the stomach contents, we identify remains of a bee, probably *Apis mellifera*, and small filaments (1 mm on average), very hard and ivory colored, probably corresponding to the gnawed endocarp of the fruit of *Strychnos brasiliensis*, a small tree known to attract domestic and wild bees

Table 1: External and craniodental measurements (in mm) for known specimens of *Abrawayaomys chebezi* and the holotype of *Abrawayaomys ruschii*, the type species of the genus.

	Abrawayaomys chebezi				*Abrawayaomys ruschii*
				Holotype	Holotype
	CEM 9970[a]	MACN 20253	CNP 3631	DZUP 584[e]	MN 23075[b]
Sex	–	Male	Male	Male	Female
Age class[c]	–	4	2	5	3
Head and body length	–	120	105	135.6	116
Tail length	–	133[d]	112	151.1	85
Hind foot length without claw	–	27.5	26	–	–
Hind foot length with claw	–	29[d]	28	33.5	29
Ear length	–	17[d]	17	18.5	20
Weight (g)	–	–	35	50	46
TL/HBL	–	1.10	1.10	1.11	0.73
Condylobasal	–	27.67	25.10	26.77	27.46
Occipital condyle width	–	6.53	6.71	7.05	8.01
Diastema	–	7.68	6.59	8.60	7.57
Palatal bridge	–	5.25	4.74	5.74	5.46
Incisive foramina length	4.40	4.65	4.25	4.87	5.33
Incisive foramina width	1.20	1.44	1.55	1.59	1.72
Breadth between M1	–	5.32	5.24	5.31	5.67
Bullar length less tube	–	4.84	4.50	–	5.48
Cranial height	11.00	9.68	–	10.00	9.94
Rostral length	–	10.94	9.51	8.54	8.26
Rostral width	5.60	5.62	5.20	5.50	5.04
Least interorbital breadth	5.90	6.02	5.72	6.14	6.29
Internal orbital length	–	9.81	9.31	10.42	10.10
Zygomatic breadth	16.00	16.99	15.44	16.70	17.20
Braincase width	–	13.67	12.84	13.15	13.18
Zygomatic plate width	–	3.56	3.24	3.82	4.34
Mandible height	–	9.03	9.47	9.14	9.18
Mandible length	–	16.56	15.25	16.89	17.30
M1 length	–	1.82	1.98	–	2.62[f]
M1 breadth	–	1.16	1.32	–	–
M2 length	–	1.32	1.42	–	1.87
M2 breadth	–	1.06	1.22	–	–
M3 length	–	0.63	0.69	–	0.93
M3 breadth	–	0.69	0.86	–	–
Upper molar row length	3.30	3.96	4.05	3.91	5.42
m1 length	–	1.82	1.98	–	2.29
m1 breadth	–	1.06	1.02	–	–
m2 length	–	1.45	1.59	–	1.91
m2 breadth	–	0.99	1.15	–	–
m3 length	–	0.89	0.99	–	1.45
m3 breadth	–	0.83	0.89	–	–
Lower molar row length	–	–	4.30	–	5.65

[a]After Massoia et al. (1991:40). [b]After Pereira et al. (2008:table 1). [c]Following toothwear classes proposed by Voss (1991). [d]Measured from dry skin. [e]After Cerboncini et al. (2014:table 1). [f]After Cunha and Cruz (1979:5).

(Carrizo and Isasmendi 1994). The gall bladder is absent. The large intestine is moderately short, about 40 mm in length; a poorly developed cecum about 18 mm in length exhibits simple, unspecialized morphology.

The glans penis in *Abrawayaomys chebezi* is barrel shaped and covered by rounded spines throughout the body (Figure 4). The dorsal surface has a distinct groove extending the length of the penis; an indistinct groove is present on the ventral surface. The crater rim is multiply divided, with the dorsal margin distinctly longer than the ventral one, which is divided by a deeply incised notch. The medial bacular mound is long and visible above the

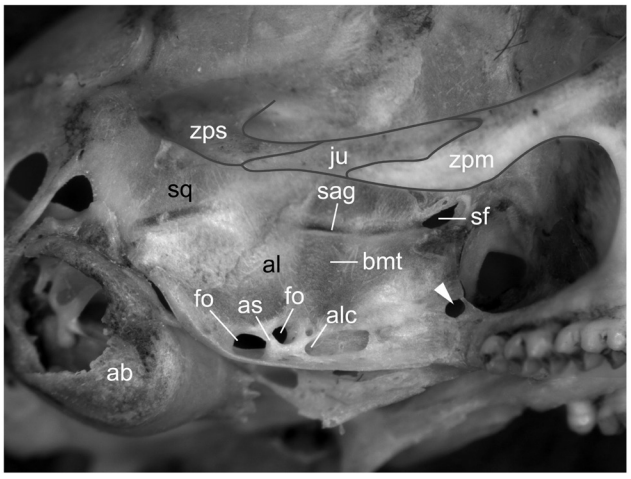

Figure 1: Squamosal-alisphenoid region of *Abrawayaomys chebezi* according to the specimen CNP 3631 from PP Urugua-í, Misiones, Argentina.
The limits of the zygomatic arch and the jugal bone are highlighted. Abbreviations: ab, auditory bulla; al, alisphenoid; alc, anterior opening of the alisphenoid canal; as, alisphenoid strut; bmt, trough for masticatory-buccinator nerve; fo, foramen ovale; ju, jugal; sag, squamosal-alisphenoid groove; sf, sphenofrontal foramen; sq, squamosal; zpm, zygomatic process of maxillary; zps, zygomatic process of squamosal. The mark points an unnamed foramen that opens in the suture between the alisphenoid and the orbitosphenoid.

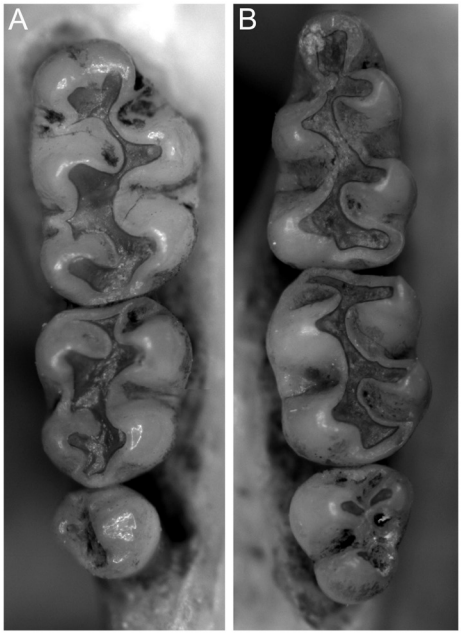

Figure 2: Right upper (A) and left lower (B) molar toothrows in *Abrawayaomys chebezi* according to the specimen CNP 3631 from PP Urugua-í, Misiones, Argentina.
The dentine was stained to obtain a better definition of the occlusal morphology.

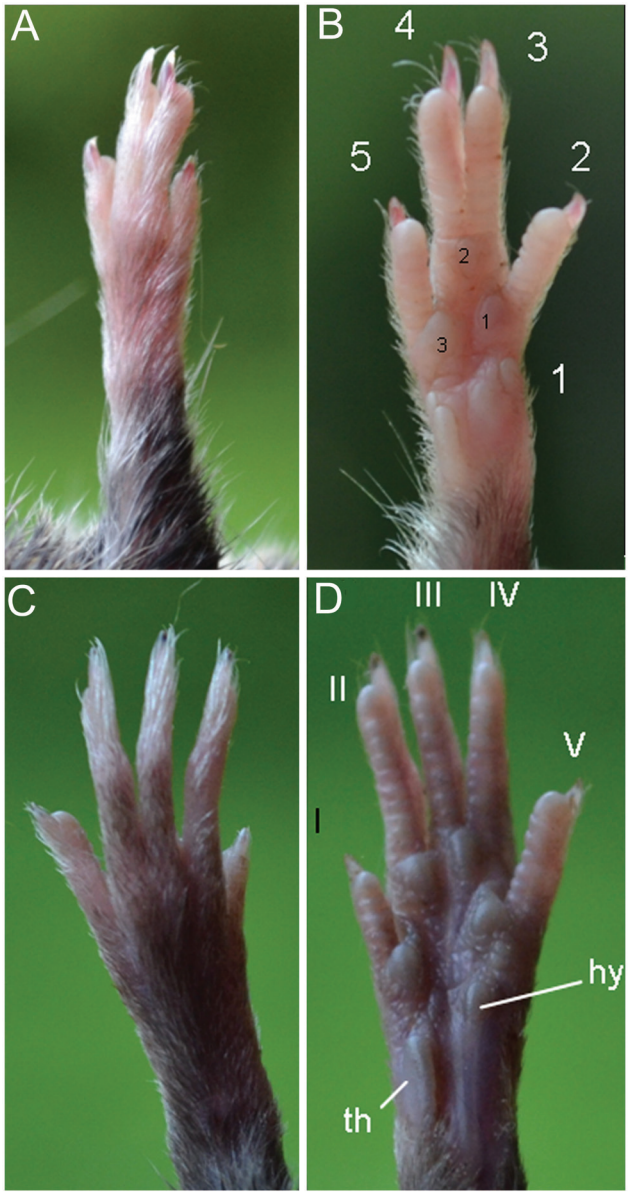

Figure 3: Fore and hind feet, dorsal (A, C) and ventral (B, D) surfaces in *Abrawayaomys chebezi* from fresh specimen CNP 3631, PP Urugua-í, Misiones, Argentina.
The manus fingers and the interdigital palmar pads are identified in Arabic numbers; the pedal fingers are identified in Roman numbers; th, thenar pad; hy, hypothenar pad.

crater rim; the lateral bacular mounds are simple, with their tips placed deep within the crater. The medial cartilaginous digit is large, nearly twice the length of the lateral ones. Urethral flaps are slightly larger than lateral cartilaginous digits. No spines are present on either lateral mounds or urethral flaps. Overall, the glans penis shares several anatomical features with those of the Thomasomyini, including the presence of spines and the multiply divided, midventrally notched crater rim, with a distinctly longer dorsal margin (Pacheco 2003).

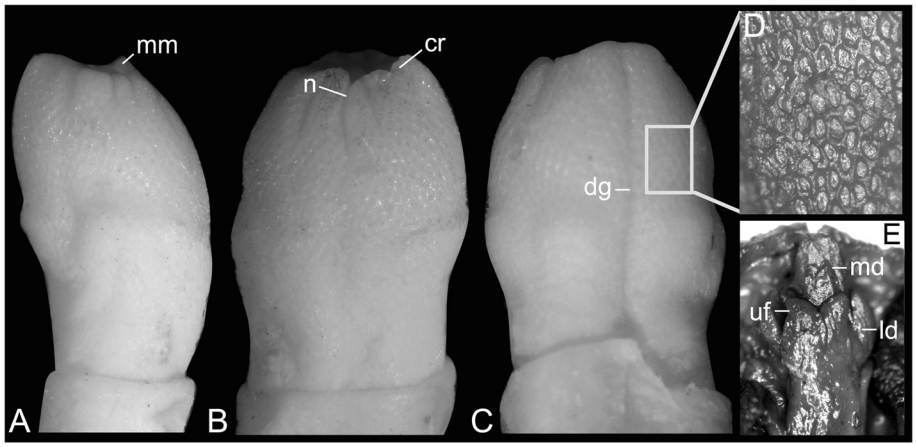

Figure 4: Lateral (A), ventral (B), and dorsal (C) views of the glans penis of *Abrawayaomys chebezi* (CNP 3631) from PP Urugua-í, Misiones, Argentina.
The inset in D shows details of the dorsal surface, covered by rounded spines; those in E depicts the lateral (lm) and medial (md) digits of the cartilaginous baculum and the urethral flaps (uf). Other abbreviations: cr, crater rim; dg, dorsal groove; mm, medial bacular mound; n, notch on midventral margin of the crater rim.

The axial skeletal counts on CNP 3631 include 12 ribs, 19 thoracicolumbar vertebrae [contrary to Pardiñas et al. (2009:47) who erroneously recorded 15], 3 fussed sacral vertebrae, and 34 (possibly 35–36) caudal vertebrae. The neural spine on the second thoracic vertebra is much longer than the spines on adjacent vertebrae. Hemal arches are present between tail vertebrae third and fourth, fourth and fifth, and fifth and sixth; hemal arches between the second and third caudal vertebrae are apparently absent (as in the holotype; Pardiñas et al. 2009). The posterior edges of the first hemal arch are extended into a distinct spinous process (*sensu* Steppan 1995:49). The tuberculum of the first rib articulates with the transverse process of both the seventh cervical and the first thoracic vertebrae. The sternum consists of an anterior manubrium, four sternebrae, and a posterior and enlarged xiphoid process. The humerus lacks an entepicondylar foramen; the supratrochlear fossa is perforated. These characters suggest that *Abrawayaomys chebezi*, like many other sigmodontine rodents of ambulatory and/or scansorial habits, retains an "all-purpose" morphology that allows it to use a variety of habitats (cf. Carrizo et al. 2013). Table 2 lists the diverse assemblage of fleas and mites collected from the skin of CNP 3631.

Abrawayaomys chebezi is known from only five localities, all entirely within the Upper Paraná Atlantic Forest or Selva Paranaense, an inland portion of the complex tropical and subtropical rainforest called Atlantic Forest (Galindo-Leal and Gusmão Câmara 2003). Collection localities in Misiones are located on the western part of the province that drains toward the río Paraná. Gil and Lobo (2012) suggested that *A. chebezi* has a potential distribution fragmented into three main areas with an extension to the neighboring country of Paraguay. We also note that Gil and Lobo (2012:53) hypothesized that the western portion of the PP Provincial Urugua-í was a favorable area

Table 2: Ectoparasites collected from *Abrawayaomys chebezi* captured in PP Urugua-í, Misiones, Argentina.

Taxonomy		Specimens recorded	Remarks
Insecta, Siphonaptera, Ctenophthalmidae	*Adoratopsylla antiquorum antiquorum*	1 Female	Usually parasitizing marsupials; first record for Argentina
Insecta, Siphonaptera, Rhopalopsyllidae	*Polygenis rimatus*	1 Male	Usually parasitizing sigmodontines; morphological variation was highlighted between Argentinean and Brazilian populations (Lareschi and Linardi 2005). The recorded specimen agrees with those from Brazil, which probably constitute a different species
Acari, Mesostigmata, Laelapidae	*Androlaelaps fahrenholzi*	>150 Females (some with eggs inside), males, and immature stages	Usually parasitizing sigmodontines; the occurrence of immature stages and adults of both sexes supports that *A. chebezi* is not an accidental host

with the capacity to support undetected populations of *A. chebezi*. The two specimens recently recorded as *Abrawayaomys ruschii* from the state of Paraná, Brazil, by Cerboncini et al. (2014) are, to our best knowledge, referable to *A. chebezi*. Although we were unable to examine these two specimens, the diagnostic traits of *A. chebezi* are evident from the figure of the skull (Cerboncini et al. 2014: figures 1 and 2). Although both individuals are very old, a principal component analysis of craniodental variables places them close to *A. chebezi* (Supporting Information 1). Additional morphological features, including the short nasals, hourglass-shaped interorbital region, and the proodont-to-orthodont upper incisor orientation, agree with *A. chebezi* rather than *A. ruschii*. If our hypothesis advanced is confirmed, then the animals from Paraná constitute the first reference for *A. chebezi* in Brazil.

The evidence at hand gives partial support regarding the existence of three discrete units within *Abrawayaomys* (Pardiñas et al. 2009, 2015). There appear to be three geographically structured morphological groups among the few known specimens, with two of these currently recognized at the species level (Supplementary Figure 4). These groups could be identified as a southern *Abrawayaomys chebezi*, a largely coastal Brazilian *Abrawayaomys ruschii*, and an interior Brazilian Minas Gerais form that is still unnamed. The distribution pattern of qualitative morphological traits suggests a tripartite division within the genus. While *A. chebezi* is characterized by its smaller molars, short nasals, hourglass-shaped interorbit region, inconspicuous dark tail with an apical tuft, proodont-to-orthodont upper incisors, and presence of an alisphenoid strut, animals from São Paulo and Rio de Janeiro are larger, have robust molars, a convergent interorbital region, and comparatively shorter tails. In contrast, populations of Minas Gerais have longer tails and entirely white apical tuft to the tail, no alisphenoid strut, and opisthodont incisors. Although intrapopulation variation is present, especially evident when comparing juvenile and adult individuals, we lack evidence that trenchant differences are involved. We assessed age variation in five skins from Sao Paulo State, four juvenile and one adult. The morphological changes observed in the tail features involved its length, pilosity, and coloration. Tail length varied from slightly longer than the combined head and body length in juveniles to clearly longer in an adult; juvenile tails are scarcely haired in contrast to a well-haired tail of an adult individual; the apical portion of the tail in juveniles was dark brown, while that of the adult is white all around for the terminal 15 mm; and, finally, the apical tuft in juveniles is almost nonexistent, while free hairs in the adult individual are 20 mm in length. We also surveyed 11 skulls from São Paulo State and recorded only one with very filiform development of the alisphenoid strut. The condition displayed by specimens from Minas Gerais where the alisphenoid strut is lacking (reviewed in Pardiñas et al. 2009) appears to represent a geographic rather than a non-geographic variation. Morphometric analysis, although based on few individuals, do not contradict these geographic groupings. Principal component (Supporting Information 1) and cluster analyses (not shown) reveal that *A. chebezi* individuals and those from Paraná state reported by Cerboncini et al. (2014) are smaller than those from Espírito Santo, Minas Gerais, and Rio de Janeiro. In addition, specimens from Minas Gerais are characterized by larger toothrows, while those of Espírito Santo and Rio de Janeiro have proportionally wider zygomatic plates and larger zygomatic breadths. Finally, the scarcely available molecular data also suggest the same three geographic groups, assuming that at least one specimen has been sequenced from each group. Cytochrome *b* variation surveyed in five animals [including the CNP 3631 (GenBank accession number xxxxxxx) plus those reported by Ventura et al. (2013)] reveals a moderate degree of differentiation – divergences of about 2.5–3% pairwise uncorrected genetic distance – among Argentinean and Brazilian populations (Supplementary Figure 4).

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We need larger series from throughout the known range of the genus to enable a more robust understanding of the alpha taxonomy of *Abrawayaomys*. It is not unreasonable to think that the genus embraces a moderate species-level diversity partially structured by the main geographic barriers that characterize southeastern Brazil. While *Abrawayaomys chebezi* could be considered a species from the interior Atlantic Forest, and *Abrawayaomys ruschii* is restricted to the Serra do Mar-Mantiqueira, those populations in Minas Gerais that inhabit the Serra do Espinhaço may represent an unnamed third species. Similar species-level scenarios are displayed by other sylvan sigmodontines generally inhabiting the range region. Both *Delomys* and *Juliomys* are well-studied examples, with the diversification process in these mice involving allopatry (Gonçalves 2006, Gonçalves and de Oliveira 2014). The morphological differences among the recognized species of *Juliomys* are subtle, mostly size aspects (one large species vs. two small species), the degree of robustness of several cranial structures (e.g., braincase, sphenopalatine vacuities), and the morphology of the interorbital region (convergent versus amphoral), among other attributes (e.g., Costa et al. 2007, Pavan and Leite 2011). The same is true for *Delomys*, which is now recognized to contain three living species (Gonçalves and de Oliveira 2014). In this context, *Abrawayaomys* emerges

Q3: Reference "Gonçalves and Oliveira (2014)" has been changed to "Gonçalves and de Oliveira (2014)" to match the reference list. Please check and confirm

as a widespread form covering 10° of latitude (Passamani et al. 2011) that deserves a closer scrutiny.

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