Short Note

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Dense sampling provides a reevaluation of the southern geographic distribution of the cavies *Galea* and *Microcavia* (Rodentia)

Abstract: The southern distribution of the small cavies *Galea leucoblephara* and *Microcavia australis* is reviewed. It has been enriched through the addition of 36 new locality records for *G. leucoblephara* and 176 for *M. australis*. Both caviomorph rodents are widespread in Patagonia – the former occurs in the northern portion of the territory, whereas the latter is recorded up to the Magellan Strait. The reference of Patagonian *Galea* populations to *leucoblephara* is still subject to confirmation. Therefore, the status of *negrensis* must be addressed in future studies. For southern *Microcavia australis* populations, a rich subspecifical scenario is proposed, including the names *australis*, *kingii*, and *nigriana*. The alpha taxonomy of this cavy needs a fresh approach that is based on a larger sample set coupled with the analysis of molecular markers.

Keywords: Caviidae; *Galea leucoblephara*; *Microcavia australis*; new distribution records; Patagonia.

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Given that we are well into the 21st century and there is a growing emphasis on disciplines such as molecular biology, phylogeography and ecology, endeavors to gather basic information regarding species distribution records may seem anachronistic. However, such data are essential as they provide the basis for biogeographic studies and for understanding the patterns of biodiversity. Extensive (i.e., dense) data on species distribution can also contribute to epidemiological programs (e.g., Carbajo and Pardiñas 2007), delimitation of areas for conservation (e.g., Richardson and Whittaker 2010), and efforts to explore the response of small mammals to recent climate change (e.g., Moritz et al. 2008).

Knowledge of the geographic distributions of small mammals in Patagonia has traditionally been limited (e.g., Osgood 1943, Hershkovitz 1962). Several factors have contributed to our poor understanding of the fauna of this area of arid grassland in the southern portion of South America, including the size of the region (~790,000 km^2), the general absence of roads, the challenging climatic conditions, and the small number of researchers working in Patagonia. An intensive survey program developed by Pardiñas and collaborators during the last decade has begun to address this situation (e.g., Pardiñas et al. 2003, 2008, 2011, Udrizar Sauthier et al. 2008, 2011, Formoso et al. 2011, Udrizar Sauthier and Pardiñas 2014). As part of this effort, here we present an exhaustive review of the taxonomy and southern range limits of the two species of small cavies that inhabit Patagonia, namely, *Galea leucoblephara* (Burmeister, 1861) and *Microcavia australis* (Geoffroy Saint-Hilare and d'Orbigny, 1833).

Cavies (family Caviidae) are rodents with a broad geographic distribution in South America, where they occupy a variety of unforested and xeric environments. The subfamily Caviinae includes three genera, *Cavia*, *Galea*, and *Microcavia*. The common yellow-toothed cavy, *G. leucoblephara*, is the most widely distributed member of the genus, ranging from the lowlands of

Bolivia and Paraguay to the Patagonian steppe in southern Argentina (Dunnum and Salazar-Bravo 2010). Its elevation to species status was first proposed based on molecular data (Dunnum and Salazar-Bravo 2010) and was later supported by morphological analyses (Ubilla and Rinderknecht 2014). The southern cavy, *M. australis*, is widely distributed in Argentina, occurring from Jujuy to Santa Cruz Province, with a limited distribution in southern Chile (Osgood 1943, Cabrera 1961, Mann 1978, Pine et al. 1979, Kelt 1996, Tognelli et al. 2001). The two species are similar in size (maximum body weight ~100 g), and both are gregarious, largely diurnal, and build complex burrows under bushes and shrubs (Rood 1970, 1972, Tognelli et al. 2001, Taraborelli et al. 2007). These characteristics may help to explain the low abundance of these species in owl pellets. Furthermore, because the animals are often patchily distributed and are difficult to catch using traditional methods (e.g., Sherman traps), their relative abundance is often underestimated when analyzing the compositions of small-mammal communities.

Our analyses examine the geographic distributions of *Galea leucoblephara* and *Microcavia australis* in Patagonia, from the Barrancas and Colorado rivers to the north up to the Strait of Magellan to the south. This region is divided from northeast to southwest into the following four major phytogeographic units: Espinal Phytogeographical Province (PP), Monte PP, Patagónica PP, and Subantártica PP (Cabrera 1976, Burkart et al. 1999). To assess the distribution of cavies in each of these phytogeographic regions, animals were captured using Sherman-like traps (8×9×29 cm), shot with an air rifle, or identified in owl pellets collected from roosts inhabited primarily by *Tyto furcata* (*sensu* Nijman and Aliabadian 2013) and *Bubo magellanicus*. The captured animals were euthanized and then prepared as museum specimens following the guidelines of the American Society of Mammalogists (Sikes et al. 2011). Specimens were deposited in the Colección de Mamíferos (CNP), and cranial and dental remains from owl pellets were deposited in the Colección de Materiales de Egagrópilas y Afines "Elio Massoia" (CNP-E), both of which are part of the Centro Nacional Patagónico in Puerto Madryn, Chubut, Argentina. To locate potential additional records for this species, an extensive bibliography search was performed and the holdings of the mammal collections in both the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN) and the Museo de La Plata (MLP; Supplemental Table 1) were examined. All records for *Galea leucoblephara* and *Microcavia australis* are listed in Supplemental Table 1 and plotted in Figures 1 and 2, respectively.

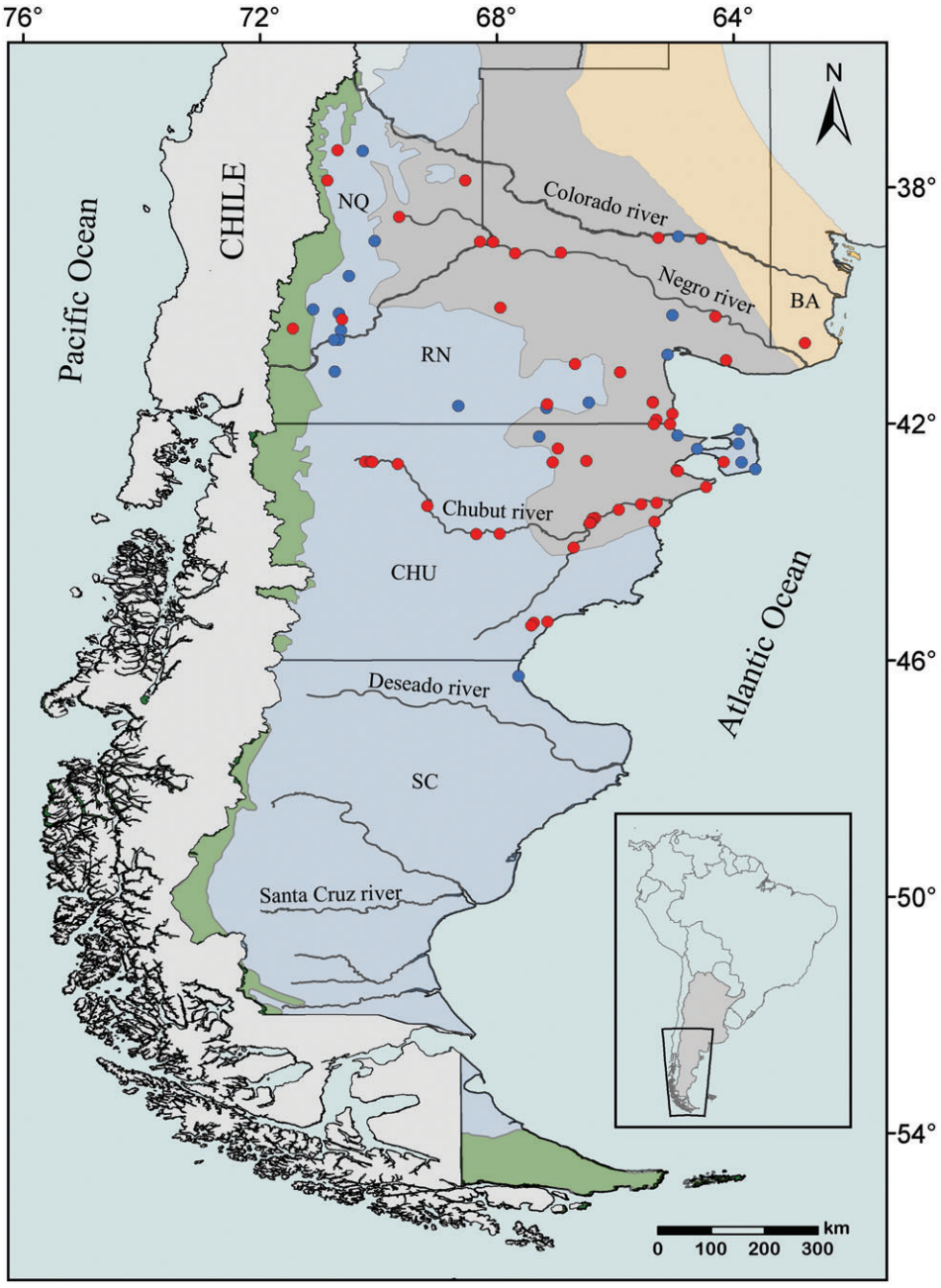
Q1: Please supply all the binominal authority for all genus/species on first mention throughout.

We compiled a total of 75 records for *Galea leucoblephara*, of which 36 (48%) represent new localities. Previously, the southern limit of this species was thought to coincide with the southern edge of the Monte PP (Pardiñas et al. 2003, Agnolin et al. 2008). However, the results of our analyses indicate that *G. leucoblephara* occurs well to the south of the Monte in the Chubut River Valley. In the southern part of its distribution, locality records are restricted to coastal areas, extending to the northern portion of the Deseado Massif (Supplemental Table 1, Figure 1). This same distributional pattern has been observed in other small mammals associated with the Monte PP, including *Akodon iniscatus* (Pardiñas 2009), *Calomys musculinus* (de Tommaso et al. 2014), *Graomys griseoflavus* (Udrizar Sauthier et al. 2011), and *Thylamys pallidior* (Formoso et al. 2011), suggesting that the Chubut River serves as a general geographic limit for small mammals in Patagonia (Figure 1). In contrast, the western distribution limits for Patagonian small mammals do not appear to be as consistent. Our data indicate that in western Neuquén Province, *G. leucoblephara* occurs near the Subantártica PP at elevations ranging up to 1650 m asl (Riscos Negros locality; Supplemental Table 1). This differs from the distributions of other small mammals associated with the Monte PP, which do not reach such altitudes (e.g., Formoso et al. 2011, Udrizar Sauthier et al. 2011).

Q2: Reference "de Tamasso et al. (2014)" has been changed to "de Tammaso et al. (2014)" to match the reference list. Please check and confirm.

A total of 250 records were compiled for *Microcavia australis*, of which 176 (70.4%) are new localities. This species and the herbivorous sigmodontine rodent *Reithrodon auritus* (see Pardiñas and Galliari 2001) are the only non-volant small mammals that occur throughout Patagonia, ranging from the Colorado River to the Strait of Magellan and from the Atlantic coast to the Andean piedmont. Their altitudinal range in Patagonia vary from sea level to more than 2000 m asl; in other areas of Argentina, such as the Puna of San Juan Province, they were detected at ~3000 m asl (Taraborelli et al. 2007). *Microcavia australis* is mostly absent in forested and ecotonal western areas (Figure 2).

The occurrence of *Microcavia australis* in southern Chile was mentioned by several authors (e.g., Osgood 1943, Cabrera 1961, Mann 1978). However, these references were performed while bearing in mind the record of this species in neighboring Argentinean localities. In fact, the only specimen documented and captured in Chilean territory is that of Reise and Venegas (1987) from Chacabuco Valley in the Aysén region. However, Sielfeld (1979) mentioned the presence of *M. australis* in a Late Holocene archaeological assemblage near the eastern entrance of the Strait of Magellan, Chile.



Q3: Part label (A) mentioned in figure caption. Please check and supply part label (A) in figure 1 and 2.

Figure 1: *Galea leucoblephara*: geographical distribution in Patagonia. A. Current (blue) and new (red) records. Abbreviations: BA: Buenos Aires province; CHU: Chubut province; NQ: Neuquén province; RN: Río Negro province; SC: Santa Cruz province. Major phytogeographic units are colored: orange: Espinal PP; gray: Monte PP; light blue: Patagónica PP; and green: Subantártica PP.

The 216 new records for *Galea leucoblephara* and *Microcavia australis* provided in this study reveal that these caviomorphs are widely distributed elements of the small-mammal fauna of Patagonia. This is in marked contrast to previously published reports, which appear to have substantially underestimated the abundance of cavies in this region. For example, while reviewing the Patagonian distribution of *G. leucoblephara*, Agnolin et al. (2008) mentioned only three records for this species in the Patagónica PP; now, a dozen such localities are known. Moreover, Dunnum (2015) reported the southern limit of the genus as northern Chubut, which is over 400 km north of the current austral limit for *Galea*. Finally, the mammalian species account for *M. australis* (Tognelli et al. 2001) includes a distribution map in which the species is absent from the eastern and southernmost portions of Patagonia.

The consequence of our incomplete understanding of distributions of small-bodied Patagonian cavies

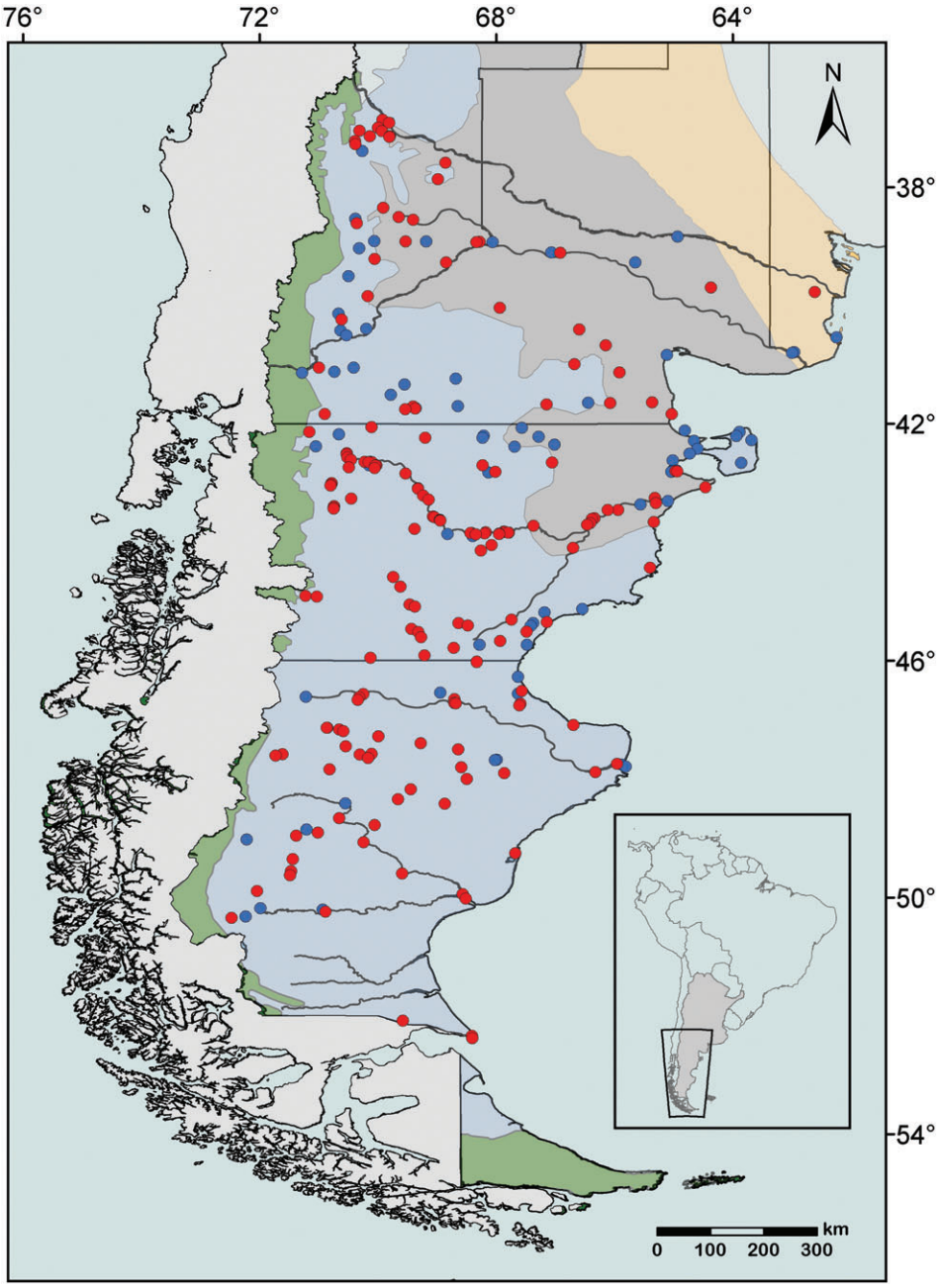


Figure 2: *Microcavia australis*: geographical distribution in Patagonia. A. Current (blue) and new (red) records. For names and color references, see Figure 1.

is not restricted to geographic issues. The assignment of Patagonian populations of *Galea* to *leucoblephara* still requires confirmation, as Dunnum and Salazar Bravo's (2010) molecular approach did not include animals from Patagonia. In particular, the status of *negrensis*, a form described by Thomas (1919) with type locality at Pilcañeu (Río Negro; not "Pilcaniyeu" as stated by Cabrera 1953:47) should be addressed by future studies. Furthermore, the rich subspecific diversity proposed for southern populations of *M. australis* – including the names *australis*, *kingii*, and *nigriana* (Thomas 1921, 1929) – requires investigation. Although the reported differences in body size and coloration used to describe these races were dismissed by Cabrera (1953:28), the alpha taxonomy of this species complex should be re-examined using larger samples and molecular analyses. As has been found for sigmodontine rodents (cf. Lessa et al. 2010), it seems likely that Patagonian cavies contain currently hidden clues to understanding the evolution of faunal diversity at extreme southern latitudes.

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Q4: References "Apfelbaum and Reig, 1989", "Bennett, 1835", "Contreras, 1964", "Cueto et al., 2008", "de Santis and Pagnoni, 1989", "de Santis et al., 1997", "Doering, 1881", "García Esponda et al., 1998", "Hatcher, 1903", "Massoia, 1988", "Massoia and Pardiñas, 1988", "Massoia et al., 1994", "Nabte, 2003", "Nabte, 2010", "Nabte et al., 2006", "Nabte et al., 2008" "Pardiñas and Galliari, 1998", "Pardiñas and Massoia, 1989", "Pardiñas and Teta, 2007", "Pardiñas et al., 2000", "Pardiñas et al., 2001", "Pardiñas et al., 2012", "Quintana, 1996" "Santillán et al., 2009", "Schiaffini et al., 2011", "Teta and Andrade, 2002", "Teta et al., 2001" "Teta et al., 2002", "Thomas, 1898", "Thomas, 1927", "Thomas and Saint Leger, 1926" and "Waterhouse, 1839" were not cited in text but listed in reference list. Please supply reference citation in text.

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Q6: Dunnum (2015) is forthcoming, and as such cannot be included in the references. If it has been published already, please update the reference accordingly.

Q5: Please supply volume number for Ref. "Burkart et al. (1999)".

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