Short Note

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New data on the endemic cricetid rodent *Holochilus lagigliai* from central-western Argentina: fossil record and potential distribution

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Abstract: The recently described cricetid *Holochilus lagigliai* is a poorly known amphibious rat to this day restricted to its type locality in Mendoza Province, Argentina. Here, we provide and discuss several new late Holocene records enlarging its past distribution to cover the north portion of the province, indicating that this rodent was widespread in a recent past. We also performed a potential distribution analysis pointing to plausible areas of occurrence in neighboring provinces. *Holochilus lagigliai* seems to be a mammal negatively affected by the growing pressure of humans on wetlands in the context of drylands that characterizes western Argentina.

Keywords: Mendoza; Oryzomyini; paleodistribution; Sigmodontinae.

Holochilus lagigliai Pardiñas, Teta, Voglino and Fernández 2013 is a unique amphibious cricetid rodent (Sigmodontinae) known from central-west Argentina. This medium-sized oryzomyine rat was based on a single recent individual collected in the 1950s in the Nihuil dam, constructed as a reservoir of the Atuel River in central Mendoza Province (Figure 1). Three lower jaws retrieved from the surface of an archaeological site, Gruta del Indio, not far from its type locality, were also referred to *H. lagigliai* (Pardiñas et al. 2013).

Efforts to find extant populations suggest that this rodent is rare or could be extinct. Field works done between February 2015 and January 2016 failed to obtain new individuals after trapping for several days in suitable habitats along the Atuel River. *Holochilus lagigliai* can be considered as a microendemic form restricted to a single fluvial system in a semiarid matrix largely modified by human agricultural activities (Pardiñas et al. 2013). Taking into account that its holotype was collected about half a century ago, the status of this rat from a conservational point of view is debatable. In this context, any data and effort in order to enlarge the knowledge about *H. lagigliai* is desirable.

Here, we document the first fossil records of *Holochilus lagigliai* which enlarge its past distribution. The studied specimens were referred to *H. lagigliai* based on the following combination of characters (cf. Pardiñas et al. 2013): skull strongly built; squared, broad, and short braincase; short and broad rostrum; interorbital margins with moderately well-developed supraorbital crests; wide and anteriorly rounded zygomatic plate; bony palate without excrescences; upper first molar with subelliptical procingulum; persistent parastyle and protostyle and free mesostyle; lower first molar with anteromedian fossetid labially displaced and typically opened; mandible robust with the coronoid nearly vertical and projected above the condyloid process; both the coronoid and the condyloid processes broad and robust; sigmoid notch broad and nearly oval; capsular projection well expressed and placed just below the sigmoid notch; upper and lower masseteric ridges typically fused at the level of the posterior root of the lower first molar extending forward as a unique ridge to the level of the mental foramen. Contrary to what was observed in the holotype (cf. Pardiñas et al. 2013), the new available skull displays some differences, such as supraorbital crests that

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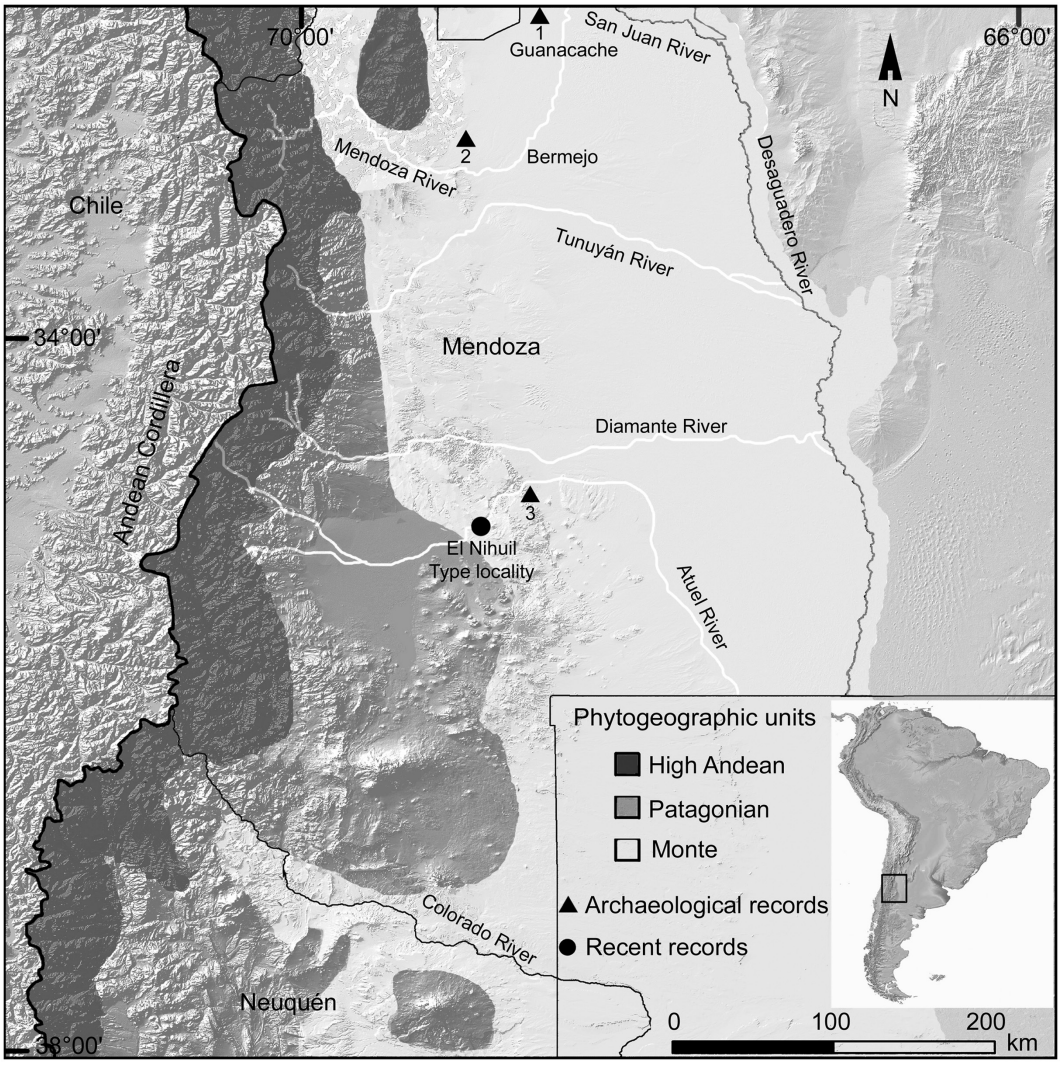

Figure 1: Map of Mendoza Province, Argentina, showing the recent and fossil locality records of *Holochilus lagigliai*. Archaeological records: 1, PA14.7 Los Altitos Negros; 2, Memorial de la Bandera; 3, Gruta del Indio.

do not continue as parietal ridges, an upper third molar that is slightly larger than the second, and hypoflexus and hypocone that are present in the upper third molar. This inconsistency, instead of questioning the assignation to *H. lagigliai*, reinforces the idea of high variability in molar morphology previously reported for the genus (Petter and Tostain 1981, Pardiñas and Galliari 1998).

We recovered a total of eight specimens of *Holochilus lagigliai* from three archaeological sites in central and north Mendoza Province, Argentina, six at Gruta del Indio, one at Memorial de la Bandera, and one at PA14.7 Los Altitos Negros (Figure 1). Gruta del Indio is an emblematic archaeological cave site located 15 km south of San Rafael (34°35′S, 68°22′W, 660 m), on the right bank of the Atuel River, in an environment related to the Monte Desert. The stratigraphic sequence has a strictly Pleistocene paleontological period from ~31,000 to ~11,000 years before present (BP) called Pre-Atuel IV, and four archaeological periods between ~11,000 years and ~200 years BP called Atuel IV–I (Semper and Lagiglia 1962–1968). The six remains of *H. lagigliai* recovered in this site were found in different late Holocene beds. An incomplete skull preserving the rostrum and both molar series (Figure 2A) plus both right and left dentaries were recorded at a depth of 20 cm, chronologically associated with the last two centuries. Within the same layer, two additional right dentary fragments were recovered. In layer 2, which is chronologically associated with the last 2000 years BP, a right dentary fragment was found. Memorial de la Bandera is an archaeological site located in Mendoza city [32°53′52″S, 68°50′46″W, 780 m above sea level (asl)], within an environmental context of low piedmont and the Monte Desert.

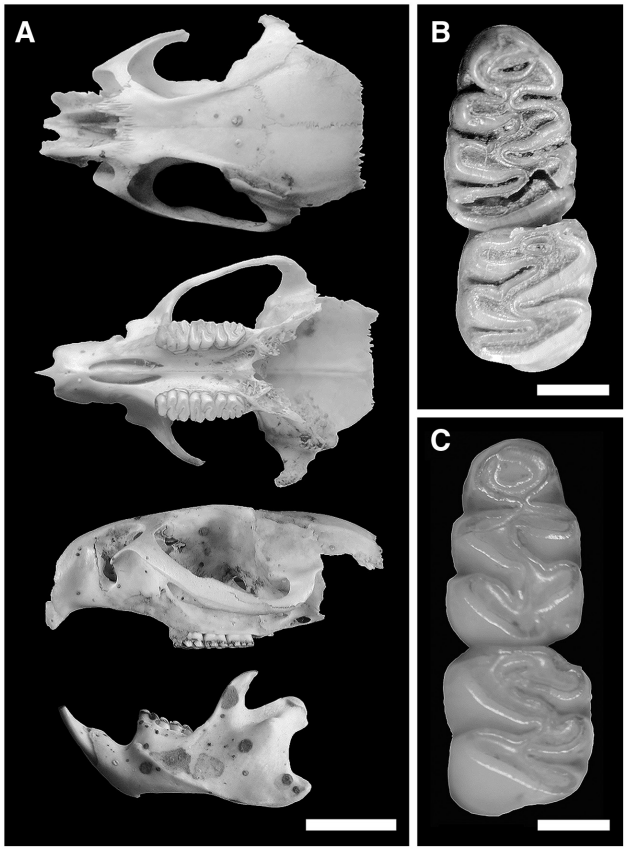

Figure 2: Remains of *Holochilus lagigliai* recovered from three archaeological sites of central and north Mendoza Province. (A) Fragmented skull (Gruta del Indio). (B) m1–2 of the right mandible (Memorial de la Bandera). (C) m1–2 of the left mandible (PA 14.7 Los Altitos Negros). Scales: a = 10 mm; b–c = 1 mm.

Archaeological sequence corresponds to late Holocene, since ~2k years BP until historical times (Chiavazza 2015). A right dentary fragment of *H. lagigliai* was found in layer 6, chronologically related to 2000–1000 years BP (Figure 2B). The third site, PA14.7 Los Altitos Negros, is an archaeological site located close to Lagunas del Rosario or Guanacache (32°00′03″S, 68°54′22″W, 540 m asl), a Monte Desert area, once plenty of developed marshes, creeks, and lagoons, but today mostly replaced by dune fields developed during the last century (Roig 1991). The eolian sand deposits of this site and the archaeological remains such as lithic, prehistorical, and historical pottery have been chronologically associated with the late Holocene, between ~1600 and ~200 years BP (Chiavazza 2007). In this site, a left dentary fragment of *H. lagigliai* was recovered from layer 3 (Figure 2C).

To explore the probable occurrence of suitable areas that could hold extant populations of *Holochilus lagigliai*, we constructed a probability distribution model for the species using maximum entropy modeling implemented in Maxent software v 3.3.3k (Phillips and Dudík 2008). Maxent software has been found to remain effective despite the use of low numbers of known presence localities in comparison with other modeling methods (e.g. Papes and Gaubert 2007, Wisz et al. 2008), and thus is recommended for our data. Models were based on both the historic record for *H. lagigliai* (type locality; Pardiñas et al. 2013) and the late Holocene locality records presented here. The associated WorldClim variables plus 19 additional bioclimatic variables – including aspects of topography and climate – at a spatial resolution of 30 arc s (Hijmans et al. 2005) – were included as environmental predictors. The maximum numbers of iterations were set to 5000 to give time for the model to converge. The performance of the model was assessed using the area under the curve (AUC) test, values for which typically range from 0.5 to 1.0 (Swets 1988), with outputs of 1.0 expected to have the highest predictive power. We ran four model replicates – constrained to the known species records – and retained the average model (Figure 3), which had high predictive power [AUC = 0.991 ± 0.007 standard deviation

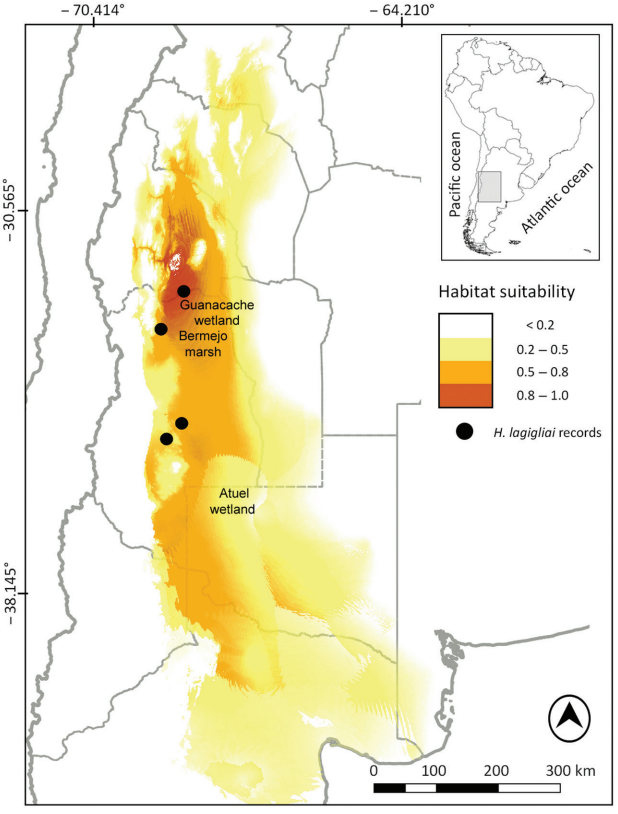

Figure 3: Predicted probability of occurrence of *Holochilus lagigliai* in Mendoza and neighbor provinces based on the habitat suitability model constructed from environmental parameters for known localities of this species.

(SD)]. Three variables contributed to 75% to the model variation. These were mean temperature seasonality range (56%), mean temperature annual range (13%), and mean temperature of wettest quarter (6%). The average distributional model predicted that the highly suitable habitats for *H. lagigliai* would be restricted today to the Guanacache wetlands in northern Mendoza Province and adjacent areas in southern San Juan Province. Areas with medium habitat quality are predicted to occur at the Atuel and Diamante river basins in southern Mendoza Province, including northwest of La Pampa Province. All these areas occur at temperate-warm climates within the Monte Desert plain environments. Thus, considering that *H. lagigliai* is a marsh rat, its distribution is likely sensitive to temperature ranges and climate seasonality, which regulate the shore habitats of Monte Desert fluvial systems (Roig et al. 2009).

The fossil records presented here indicate that *Holochilus lagigliai* had a larger distribution in central and north Mendoza Province during the late Holocene. Particularly important are the recording localities of this rat in two other fluvial systems, Mendoza and San Juan rivers, in addition to the Atuel River (all tributaries of the Desaguadero River), the locality of last occurrence of the species (Pardiñas et al. 2013). Marsh rats are closely allied with mesic environments, such as grassy marshes, gallery forest along watercourses, and flooded savannas (Massoia 1976). The dynamic flooding episodes of the aforementioned rivers generated the wetlands' so-called "Bañados del Atuel," "Ciénaga del Bermejo," and "Lagunas del Rosario o Guanacache." The development of these wetlands can be attached to some climatic fluctuations that happened during the Pleistocene and Holocene (e.g. González 1994). In addition, during historical times, both climate change and anthropogenic activity yielded expansion and retraction events of these marshes (Roig 1991, Prieto and Rojas 2012). From the 17th to the mid-18th centuries, the low streamflow of the Mendoza River and its Bermejo marsh were related to the glacier advances of the dry and cool event of the Little Ice Age, due to which the lower summer temperatures could have limited snowmelt of the Andean mountains (Prieto and Rojas 2012). Between the end of the 18th and the mid-19th centuries, the wetland had been considerably enlarged because of increased flows of the Mendoza River and turnouts of the river into the swamp to prevent flooding in the city of Mendoza (Prieto and Rojas 2012). From the mid-19th to the 20 centuries, the Bermejo marsh was gradually drained, first by the construction of channels and ditches, and finally by installing dams in the Mendoza River (Prieto and Rojas 2012). The Atuel, Diamante, Tunuyán, and San Juan Rivers have also been dammed during the 20th and the 21st centuries for utilization by agriculture and cities, decreasing its flows, causing the reduction or disappearance of extensive wetlands in the region, and partially disconnecting the Desaguadero basin during most part of the year (Roig 1991).

The aforementioned wetlands served as refuges for relictual populations of some subtropical mammals adapted to mesic conditions within the arid context of the Monte Desert, such as the marsupial *Lutreolina crassicaudata* (Desmarest, 1804), and two large semiaquatic caviomorph rodents, *Myocastor coypus* (Molina, 1782) and *Hydrochoerus hydrochaeris* (Linnaeus, 1766), that had patchy records in Mendoza Province (Roig 1991). However, as a consequence of the disturbed environmental context mentioned above, *H. hydrochaeris* and *L. crassicaudata* were extirpated from Mendoza (Roig 1991). Could the marsh rat have suffered the same fate? Three field trips planned to capture *Holochilus lagigliai* in La Pampa and Mendoza Provinces yielded no specimens. In addition, no specimens of *H. lagigliai* were found through dense trapping methods and modern pellet samples of raptor birds recovered near the three mentioned archaeological sites (Fernández et al. 2009, Rodríguez 2011, López and Chiavazza 2016, López et al. 2016). In sum, despite the intensity of sampling in the area, no current records of *H. lagigliai* have been obtained.

Episodes of expansion and contraction of *Holochilus* populations during the climatic global events of the late Holocene have been recorded for the southernmost species of the genus, *H. vulpinus* (Brants, 1827). This marsh rat used the Colorado, Negro, and Limay rivers as fluvial corridors, during the warm and humid conditions of the Medieval Climate Anomaly between the 9th and the 12th centuries, to penetrate in northern Patagonia (Fernández et al. 2011, Pardiñas and Teta 2011, cited there as *H. brasiliensis* (Desmarest, 1819)). In addition, during the same time period, this species was extensively recorded in the Pampa de Achala, a hilly plateau in western Córdoba Province, under the same warm and humid episode (Teta et al. 2005, cited there as *H. brasiliensis*). *Holochilus vulpinus* populations disappeared from northern Patagonia and Pampa de Achala during the dry and cool event of the Little Ice Age between the 16th and the 19th centuries (Teta et al. 2005, Fernández et al. 2011, Pardiñas and Teta 2011). However, contrasting with *H. lagigliai*, *H. vulpinus* retained an important area of distribution in central-eastern Argentina (Gonçalves et al. 2015).

The evaluation of the fossil record of *Holochilus lagigliai* in combination with the distribution modeling suggests that this species suffered an important

contraction in its distribution, being today restricted to few suitable habitats along the Atuel River. The probable scenario faced by this marsh rat was triggered by extensive anthropic changes – mostly the expansion of the agricultural frontier – in the drylands of the Andean piedmont.

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