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Distribution of sigmodontine rodents in Northwestern Argentina: main gaps in information and new records

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Abstract

Many uncertainties remain regarding our knowledge of sigmodontine rodent distributions in Northwestern Argentina. Most of the available information has never been critically evaluated. By reviewing the published literature and overlaying this information with other spatial layers (political, environmental, infrastructure, protected areas, and topographic layers), we identified information gaps and added new localities. The new records were obtained through field surveys, including captures and owl pellet samples. In the literature, we found 561 localities, most of them published in the past decade. These records come mainly from low-altitude areas in Salta province, as well as some higher-altitude belts in Yungas, and strongly associated with roads. Records from protected areas were scarce. *Akodon*, *Calomys*, *Oligoryzomys*, and *Phyllotis* were recorded for most of the localities. We add 18 new localities for 14 species, including the first records of *Akodon dolores* in Tucumán province, *Necromys lasiurus* in Santiago del Estero and Tucumán, and *Calomys lepidus* in Catamarca. We add records for poorly known species such as *Andalgalomys olrogi* in the Capital department (Catamarca) and *Auliscomys sublimis* and *Neotomys ebriosus* in Cochinoca (Jujuy) and La Poma (Salta). We emphasize the need for more surveys to obtain an adequate knowledge of the distribution of most sigmodontines.

Keywords: Akodontini; Cricetidae; Geographical Information Systems (GIS); new localities; Oryzomyini; Phyllotini.

Introduction

Sigmodontinae rodents represent almost 30% of the mammals recorded in Northwestern Argentina (NWA) (Barquez et al. 2006a with modifications). This highly diverse group includes small- and medium-sized species that are distributed across all of the northwestern environments, with the exception of the extreme high altitudes (above 6000 m) found in the western Andes. Although many species of the groups represent key elements in their communities and have also been identified as vectors of several human diseases, sigmodontines are among the least-known mammals in the region. Northwestern Argentina, a physiographically complex region, is an important area for understanding the evolution and biogeography of the sigmodontines of the eastern slopes of the central Andes. This relatively small area of the continent contains not less than 50 species of the group (Appendix I), many of them exclusive for this area (Barquez et al. 2006a, Jayat et al. 2007a, 2008a, 2010), and constitute an altitudinal (between high-altitude open areas and low-altitude forested areas) and latitudinal (between tropical and template regions) transition zone. Adding to the importance of NWA towards the understanding of the sigmodontines is that a number of nominal forms have their type localities in this region (Thomas 1897, 1919b, 1921a, Allen 1901, Cabrera 1926, Mares and Braun 1996, Jayat et al. 2007a, 2008a, Mares et al. 2008). However, considerable uncertainties still exist for most of the representatives of this group regarding such basic subjects as taxonomy and distribution (Musser and Carleton 2005, Barquez et al. 2006a).

Several contributions have significantly enhanced our knowledge regarding sigmodontine distributions in NWA (Pearson 1958, Hershkovitz 1962, Myers 1989, Mares et al. 1997, Díaz et al. 2000, Jayat et al. 2006, 2008b, Díaz and Barquez 2007) and allow a general understanding of the subject to be formed. However, most of the available information has not yet been critically evaluated and, therefore, it remains difficult to know where further efforts should most effectively be directed.

In recent years, some contributions have attempted to characterize environmental units in the region based upon their sigmodontine fauna (Jayat et al. 2008b) or have modeled the entire potential and actual distributions of certain species (Porcasi et al. 2005, Jayat and Pacheco 2006, Jayat et al. 2009a). However, the fact that such studies have tended to discover taxa previously unrecorded in their study areas (Barquez et al. 2006b, Jayat et al. 2006) or have even required description of new species (Jayat et al. 2007a,

2008a) clearly indicates our limited current state of knowledge.

This situation has clearly had a negative impact on the development of other research areas such as taxonomy (Jayat et al. 2007b, 2009b, 2010), biogeography (Ojeda and Mares 1989, Ojeda et al. 2008, Jayat et al. 2008b, 2009a,b) and paleontology (Ortiz and Pardiñas 2001, Teta and Ortiz 2002, Ortiz and Jayat 2007), and has also prevented objective evaluations of conservation status for many species in the region (Diaz and Ojeda 2000, Ojeda et al. 2003, Tabeni et al. 2004).

In this contribution, we analyze all of the available published information regarding distribution of sigmodontine rodents in NWA, looking for patterns in the inventories and attempting to identify the most important gaps in information in a temporal, spatial, and taxonomic framework. Based upon this analysis, we add new records for several sigmodontine species and comment upon their relevance for this geographical area.

Materials and methods

We reviewed all the available published literature containing distributional data for sigmodontine rodents in NWA and built a database with geo-referenced localities (the complete list of bibliographic sources and localities are available upon request). Using Geographical Information Systems (GIS), this information was superimposed upon other spatial layers including political (provinces, departments), environmental (ecoregions, phytogeographical units), infrastructure (highways, cities), protected areas (municipal, provincial, national, and international), and topographic (altitude, slope) layers. To evaluate the sampling effort in the region, we overlapped a grid (with cells of 10×10 km) with the surveyed localities and counted the number of cells with at least one locality and the number of localities by cell.

The coordinates of localities regarding rodent distributions were taken from the literature, obtained from geographic maps from the Instituto Geográfico Militar of Argentina (IGM), or taken by the Global Positioning System in the field. The locations of official political boundaries and infrastructure features – including national and provincial highways, main towns (500–5000 residents) and cities (>5000 inhabitants) in the study area – were also obtained from layers produced by the IGM. The layers representing ecoregions (Burkart et al. 1999), protected areas, and phytogeographical units were obtained from those generated by the GIS maintained by the Fundación ProYungas and from the work of Brown and Pacheco (2006). Altitude and slope grids were obtained from the digital elevation model produced by NASA (http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp).

For the GIS analysis we used ArcMap (version 9.3 ESRI, Redlands, CA, USA). The distances between infrastructure features were obtained with the ''Euclidean Distance'' function and the overlap between the surveyed localities and the various covertures were calculated using ''Extract Values to Points'' for raster layers and the ''Join'' function for vector layers. The number of cells with one or more localities and the number of localities by cell were obtained by using ''select by location'' and the function ''join based on spatial location''.

The new records were obtained through field surveys conducted during the past five years and which have included captures and collection of owl pellets for analysis. All of the locality data for new records, along with coordinates, are given in the gazetteer and included in Figure 1. We identified the material collected taxonomically through comparison with reference specimens from Argentine museums (Colección Mamíferos Lillo, San Miguel de Tucumán and Museo Argentino de Ciencias Naturales ''Bernardino Rivadavia'', Buenos Aires) and bibliographic sources.

For each species we discuss the previously known distribution in NWA, the new records, and comments about their relevance. The specimens examined and discussed in the new records are deposited in the Colección de Mamíferos of the Centro Nacional Patagónico (CNP), Puerto Madryn, Chubut, Argentina, with the collection of pellet samples deposited in the Colección de Egagrópilas y Afines ''Elio Massoia'' of the Centro Nacional Patagónico, Puerto Madryn, Argentina (CNP-E).

Results

General patterns for localities in the literature

We found 561 localities in NWA with at least one recorded sigmodontine species, with the highest number of these situated in the province of Salta (29.6%), but with similar proportions in the provinces of Jujuy (23.9%), Tucumán (23.9%), and Catamarca (20.5%). Notably, the province of Santiago del Estero represented only 2.1% of the localities, with information available for only nine of its 25 political departments, and with seven of these having only one record (Figure 1). There are distributional data for most of the political departments of Salta, Jujuy, Tucumán, and Catamarca, but the great majority of the localities are concentrated in only a few of them (Table 1).

The first records for sigmodontines in NWA were published at the end of the 19th century (Thomas 1897, 1899). Up until 1950 the number of known localities for the region was very scarce, with most of them recorded and published by Oldfield Thomas (Thomas 1906, 1912, 1913, 1916, 1918, 1919a,b,c,d, 1920, 1921a,b, 1925, 1926). Minor contributions for this early period were published by Allen (1901), Cabrera (1926), Yepes (1933, 1935), and Sanborn (1947a,b). After 1950, and prompted mainly by the review papers of Pearson (1958) and Hershkovitz (1962), there was a growth trend in research regarding sigmodontine distributions, with several new localities reported up until the early 1980s (Massoia and Fornes 1965, Massoia 1976, Barquez et al. 1980, Mares et al. 1981). For this period, the number of studied sites was more than five times higher than in the previous one. Although several authors published some localities after 1981 (Barquez 1983, Piciucchi de Fonollat 1984, Piciucchi de Fonollat et al. 1985, Soncini et al. 1985, Massoia 1987), this research trend really only stabilized at the end of this

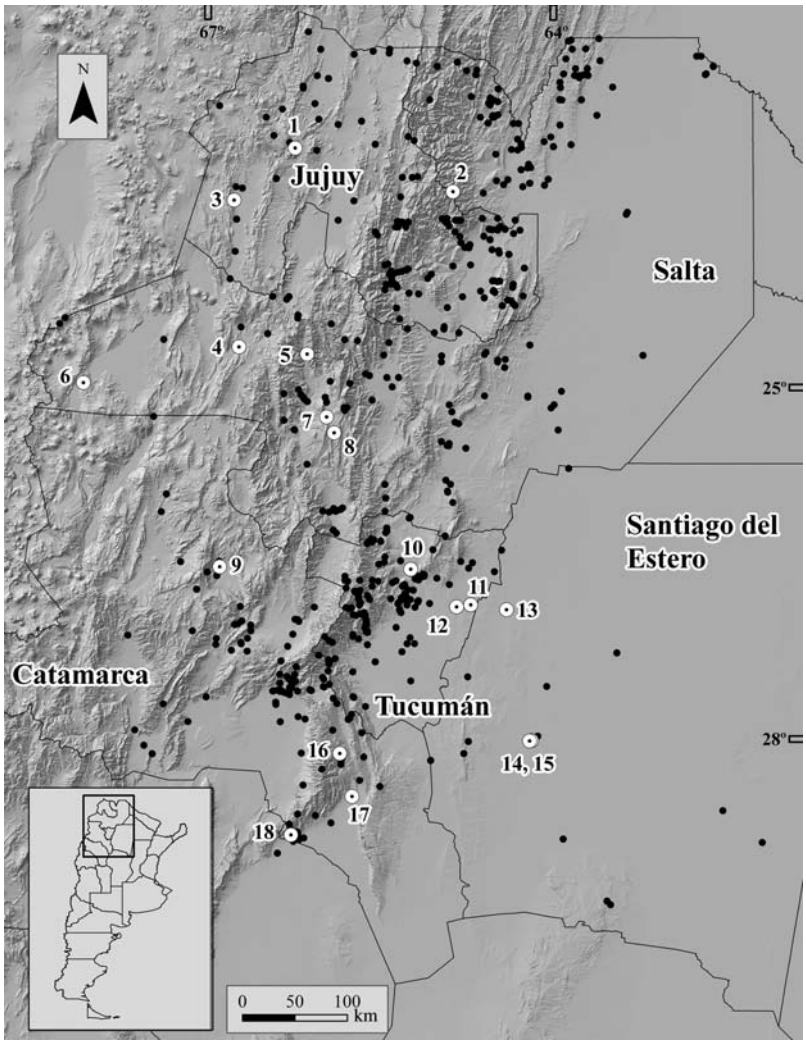

Figure 1 Collecting localities for sigmodontine rodents in Northwestern Argentina. Solid circles indicate the records obtained from the literature, and open circles indicate new records. Numbers correspond to those in Appendix II.

decade (Massoia 1988, Olds 1988, Anderson and Olds 1989, Liascovich et al. 1989, Myers 1989, Ojeda and Mares 1989, Piciucchi de Fonollat et al. 1989). Most of 1990s were relatively unproductive, with many contributions but small numbers of new published localities (Barros et al. 1990, Heinonen and Bosso 1994, Hershkovitz 1994, Massoia 1994, 1998, Braun and Mares 1995, Mares and Braun 1996, Espinosa et al. 1997, Massoia et al. 1997, Díaz and Barquez 1999, Díaz et al. 1999, Piciucchi de Fonollat and Marigliano 1999), except the studies of Myers et al. (1990), Capllonch et al. (1997), Mares et al. (1997), and Díaz (1999). The first 10 years of the 21st century have been the most productive, adding more than one-third of all of the known localities for NWA (Díaz et al. 2000, 2009, Ortiz et al. 2000, Cirignoli et al. 2001, Ortiz and Pardiñas 2001, Pardiñas and Galliari 2001, Pardiñas and Ortiz 2001, González-Ittig et al. 2002, Dragoo et al. 2003, Gil and Heinonen Fortabat 2003, Lanzone and Ojeda 2005, Porcasi et al. 2005, Barquez et al. 2006b, Jayat et al. 2006, 2007a,b, 2008a,b, 2009a,b, 2010, Díaz and Barquez 2007, Lanzone et al. 2007, Rivera et al. 2007, Teta et al. 2007, Braun et al. 2008, D'Elía et al. 2008, Ferro and Barquez 2008, Mares et al. 2008, Ferro et al. 2010) (Figure 2A).

The altitudinal distribution of the localities recorded is uneven, with a majority situated below 1500 m elevation (58%). Only 14% of the records are for above 3000 m, and there are no citations for the 4750–5500 m interval. Several 250 m altitudinal belts are almost entirely unsurveyed in the region, having less than 10 records (e.g., 0–250 m, 4000–4250 m, 4500–4750 m and 5500–5750 m intervals) (Figure 2B). The record at highest altitude in NWA corresponded to *Phyllotis xanthopygus* (Watherhouse), from Volcán Socompa at 5570 m elevation. It is important to highlight that approximately 50% of the surveyed localities are situated in areas with slopes less than 5% and approximately 76% from areas with slopes less than 20%.

Most of the reported localities are found in the Yungas ecoregion (49.2%), many of them from Bosque Pedemontano (n=144) and Pastizales de Neblina (n=107), less from Selva Montana (n=87), and 29 from Bosque Montano altitudinal belts. Monte de Sierras y Bolsones and Chaco Seco ecoregions represented 14.6% and 11.6% of the localities, respec-

Table 1 Number of localities for sigmodontine species found in the literature discriminated by political limits (provinces and departments).

Salta Province		Jujuy Province		Tucumán Province		Catamarca Province		Santiago del Estero Province	
Department	No. Loc	Department	No. Loc.	Department	No. Loc.	Department	No. Loc.	Department	No. Loc.
Gral. José de San Martín	32	Santa Bárbara	25	Tafí del Valle	30	Andalgalá	42	Guasayán	3
Orán	23	Ledesma	23	Trancas	20	Belén	23	Quebrachos	2
Anta	15	Dr. Manuel Belgrano	17	Yerba Buena	17	Capayán	18	Atamisqui	1
Santa Victoria	15	Tilcara	11	Tafí Viejo	15	Ambato	8	Banda	1
Cachi	11	Rinconada	10	Burruyacu	13	Pomán	6	Figueroa	1
Los Andes	11	Valle Grande	8	Monteros	13	Santa María	5	General Belgrano	1
Metán	10	Tumbaya	8	Lules	7	Antofagasta de La Sierra	4	General Taboada	1
Cafayate	9	El Carmen	7	Chicligasta	5	Tinogasta	4	Pellegrini	1
Rivadavia	6	Humahuaca	6	Alberdi	3	Paclín	3	Río Hondo	1
Rosario de Lerma	6	Yavi	5	Capital	3	Capital	1		
Rosario de la Frontera	5	Susques	5	Leales	3	Fray Mamerto Esquiú	1		
Chicoana	4	Cochinoca	5	Famaillá	2	La Paz	1		
Iruya	4	San Pedro	3	Cruz Alta	1	Valle Viejo	1		
Cerrillos	3	Santa Catalina	2	La Cocha	1				
Candelaria	2	San Antonio	2	Río Chico	1				
General Güemes	2			Simoca	1				
Guachipas	2								
La Poma	2								
Molinos	2								
Capital	1								
La Caldera	1								
San Carlos	1								

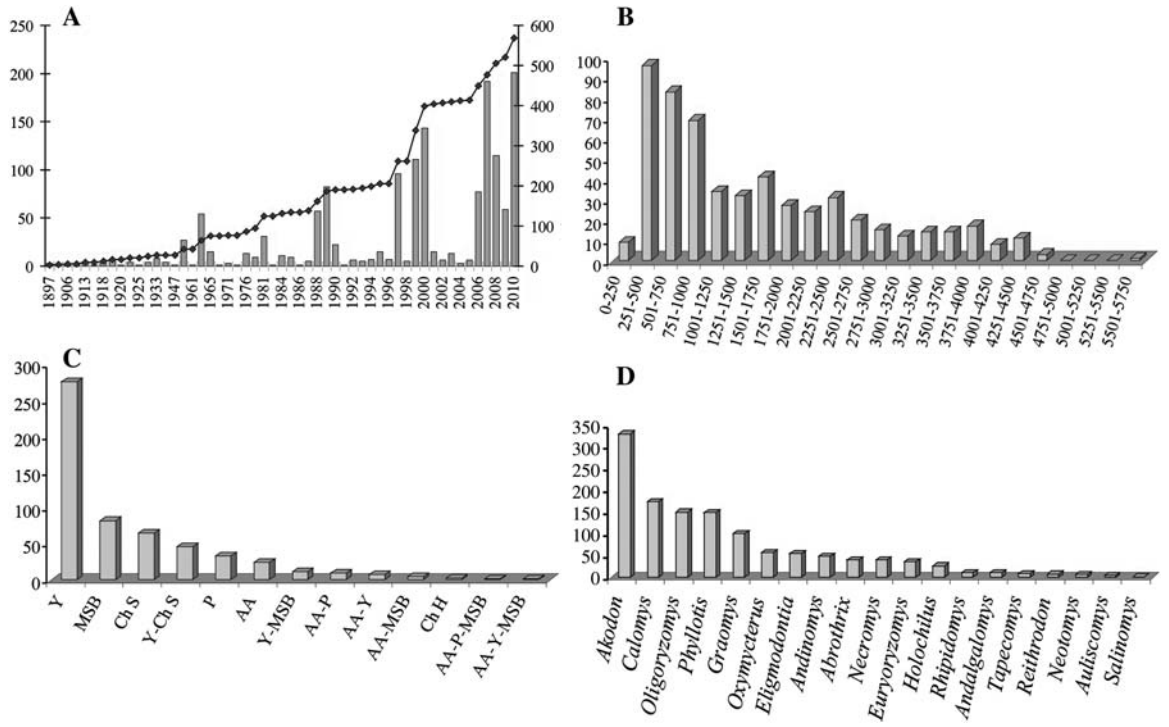

Figure 2 Frequency distribution graph of the collecting localities in Northwestern Argentina obtained from the literature by (A) year of publication (bars indicate the total number of localities published by year and the solid line the cumulative curve of the new records), (B) altitudinal belts, (C) ecoregions (Y, Yungas; MSB, Monte de Sierras y Bolsones; Ch S, Chaco Seco; P, Puna; AA, Altos Andes; Ch H, Chaco húmedo. Initials separated by a hyphen represent ecotones between the ecoregions), and (D) genera.

tively, and the remaining ecoregions (Altos Andes, Puna, and Chaco Húmedo) all represented less than 6%. Transitional areas between Yungas and Chaco Seco ecoregions were also important in terms of the number of localities for which sigmodontines were recorded (8.2%). In Chaco Seco, most of the localities were grouped in Chaco Semiárido (n=29) and Chaco Serrano (n=21) environments, with few in Chaco Árido (n=10) (Figure 2C).

Nineteen genera of sigmodontines have been recorded in NWA but most of the distributional information for this region has been recorded for *Akodon* Meyen, *Calomys* Waterhouse, *Oligoryzomys* Bangs, and *Phyllotis* Waterhouse. *Akodon* is the best-represented genus, with 330 localities recorded, whereas the other three genera were recorded in a similar number of localities (n=174, 150, and 148 localities, respectively). Very poorly represented genera include *Andalgalomys* Willams and Mares, *Auliscomys* Osgood, *Neotomys* Thomas, *Reithrodon* Waterhouse, *Rhipidomys* Tschudi, *Salinomys* Braun and Mares, and *Tapecomys* Anderson and Yates, all of which possess less than 15 records from across the entire study area (Figure 2D).

There is a strong association between the surveyed localities and highways in the region. Approximately 42% of the records are located less than 1 km from the main highways, and 85% of them are closer than 10 km (Figure 3). There is also some spatial association between the localities surveyed and main cities and towns, but this relationship is weaker. In general, the number of studied localities decreases with distance, with almost 38% of the records located closer than 10 km to the major cities, and 22% located at a distance between 10 and 20 km. However, at further distances there are still many localities where studies have occurred (e.g., 20% between 20 and 40 km).

Records regarding sigmodontine distributions in protected areas are scarce. Only 70 localities studied are situated in areas under the jurisdiction of the National Protected Areas System (40 in national, 29 in provincial, and only one in municipal parks), with 77 localities inside of internationally protected areas. However, 22 of these localities are shared by both systems.

The analysis of sampling effort indicated that only 7% of cells (350 of 4914) had at least one locality with sigmodontines. Of this small fraction, more than 65% had only one locality, 17 being the maximum number of localities by cell.

New distributional records

Based on the previous results, here, we add 18 new records for 14 species of sigmodontines in the study area (Appendix II and Figure 1).

Order Rodentia Bodwich, 1821
Family Cricetidae Rochebrune, 1883
Subfamily Sigmodontinae Wagner, 1843
Tribe Akodontini Vorontsov, 1959
Akodon dolores Thomas, 1916

Previously-known distribution in NWA Only six recorded localities in Catamarca and Santiago del Estero

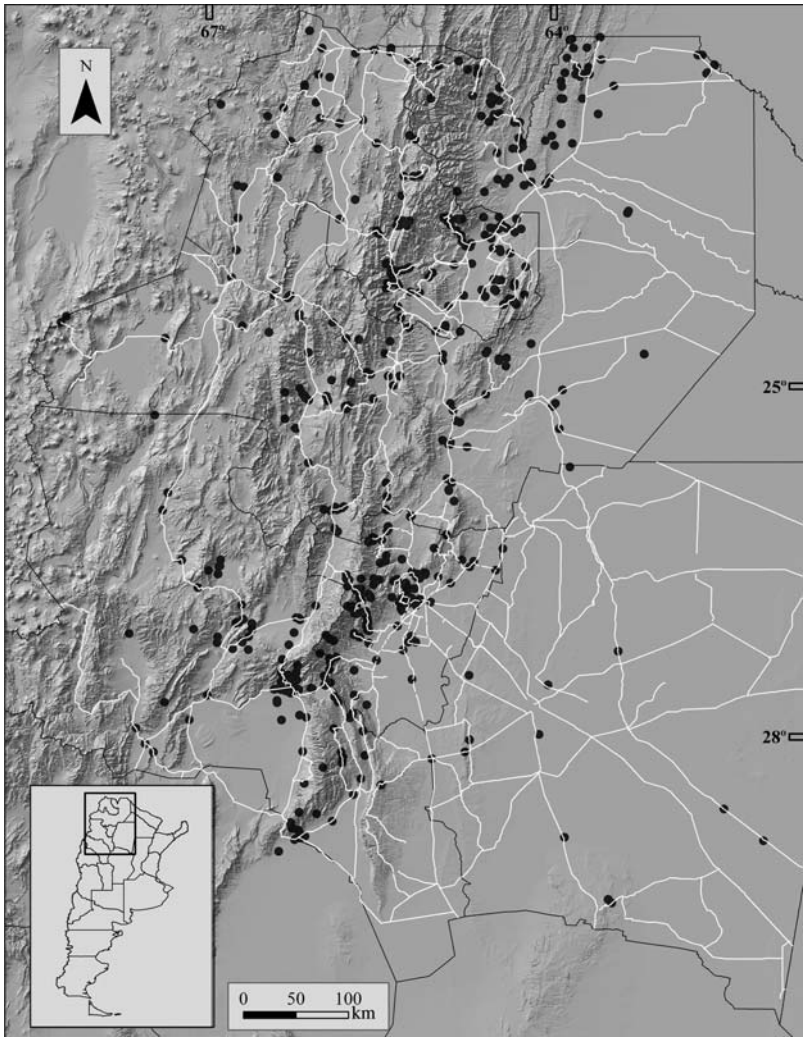

Figure 3 Topological relationship between the collecting localities of sigmodontine rodents in Northwestern Argentina obtained from the literature and the main highways of the region.

provinces, always below 700 m elevation, in Chaco-type environments (Mares et al. 1997, Braun et al. 2008).

New records Catamarca province – Trampasacha, 614 m (CNP 2355). Santiago del Estero province: approximately 30 km to the north of Pozo Hondo, along route 34, 254 m (PEO-e 289); INTA ''La María'' Research Station, 1.2 km to the west of the station entrance, 72 m (CNP 2356); INTA ''La María'' Research Station, 2.9 km to the west of the station entrance, 137 m (CNP 2357). Tucumán province – approximately 4 km to the northwest of Las Cejas, 348 m (PEO-e 294).

Comments Here, we add the first records for Tucumán province and the Capital and Jimenez departments in Santiago del Estero province. The vicinities of Pozo Hondo and Las Cejas represent the northernmost localities recorded for the species. These records correspond to fragmentary material recovered from owl pellet samples. Morphology (including a broad interorbital region with edges squared but not beaded, a wide and vertically oriented zygomatic plate, and a mandible typical of the *Akodon varius* group) and measurements of the specimens examined closely match those of *Akodon dolores* (Figure 4, Table 2). The new localities are within approximately 100 km of places where the species was previously recorded (Braun et al. 2008).

Akodon spegazzinii Thomas, 1897

Previously known distribution in NWA Although previously recorded throughout the region, with a few records for the northern part of the study area in Jujuy and Salta provinces (Myers et al. 1990, Abdala and Díaz 2000, Díaz et al. 2000, Gil and Heinonen Fortabat 2003, Díaz and Barquez 2007), recent revisionary reports restricted the species to central-south NWA, at altitudes from 350 to more than 3400 m in Catamarca, Salta, and Tucumán provinces (Jayat et al. 2008b, 2010). Most of the records come from all altitudinal belts in the Yungas ecoregion, but some specimens were recorded in Chaco Serrano-Yungas transitional areas

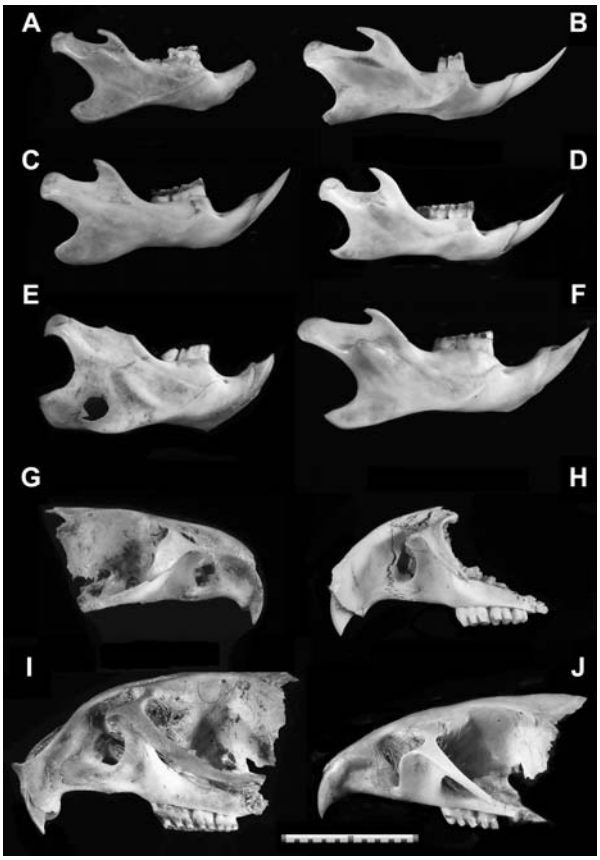

Figure 4 Skull and mandible elements of the specimens obtained at the new localities: A and G, *Andalgalomys olrogi* from Catamarca; B, *Necromys lactens* from Las Juntas; C *Auliscomys sublimis* from La Poma; D, *Akodon dolores* from Las Cejas; E and I, *Neotomys ebriosus* from Guairazul and La Poma; F and H, *Graomys griseoflavus* from La Poma and Valle del Tonco; J, *Necromys lasiurus* from Las Cejas. Scale bar=10 mm.

and in relatively humid grasslands in Monte de Sierras y Bolsones and Puna environments (Jayat et al. 2010).

New records Tucumán province – approximately 12 km to the east of Los Ralos, along route 303, 421 m (PEO-e 290).

Comments This locality places the species in the Chaco Seco ecoregion, an environment without previous records of its presence, and is the first record for Cruz Alta department. Many morphological characteristics, such as a relatively elongated incisive foramina, relatively narrow zygomatic notches, interorbital region hourglass shaped (with rounded or slightly squared margins and without overhanging borders), and a mesopterygoid fossa of intermediate breadth were observed in the single specimen examined. All the measurements taken closely match the registered values for this species in Tucumán province (Table 2).

Necromys lactens (Thomas, 1918)

Previously known distribution in NWA Many records for Catamarca, Jujuy, Salta, and Tucumán provinces (Díaz et al. 2000, Jayat et al. 2006, 2008b, Díaz and Barquez 2007), closely associated with high-altitude grasslands in the uppermost belt of Yungas and transitional areas, mainly between 1400 and 3100 m elevation (Jayat and Pacheco 2006).

New records Catamarca province – 3 km south of Las Juntas, 1654 m (PEO-e 247).

Comments The particular habitat preferences of this species create a ''patchy'' distribution in mountaintop grasslands (Jayat and Pacheco 2006). This record adds information for a large patch of grassland in central Sierra de Ambato. This locality fell inside the area considered as suitable (80–82 threshold) in the DOMAIN climatic envelope that represents the potential distribution of the species (Jayat and Pacheco 2006). The specimens possess characteristics diagnostic of the species, including prominent and backward-oriented capsular projection of the mandible, broad molars, and M1-m1 with anteromedian flexus/flexid absent or vestigial (Figure 4).

Necromys lasiurus (Lund, 1840)

Previously known distribution in NWA Catamarca province, in high-altitude grasslands of the Yungas ecoregion (Jayat et al. 2006, 2008b, D'Elía et al. 2008).

Table 2 Skull measurements for some of the species recorded in owl pellet samples.

	Akodon dolores n; x±sd; r	*Akodon spegazzinii* n; x±sd; r	*Necromys lasiurus* n; x±sd; r	*Oligoryzomys* cf. *O. flavescens* n; x±sd; r
IOC	5; 4.82±0.12; 4.64–4.96	1; 4.44	6; 4.49±0.08; 4.44–4.64	3; 3.62±0.27; 3.34–3.88
RW2	4; 4.95±0.12; 4.82–5.10	–	5; 4.98±0.24; 4.68–5.34	3; 4.33±0.06; 4.26–4.38
DL	6; 6.87±0.56; 6.16–7.62	1; 5.94	6; 7.21±0.43; 6.74–8.00	5; 5.66±0.52; 4.76–6.02
MTRL	6; 4.98±0.09; 4.88–5.08	1; 4.28	6; 5.10±0.13; 4.92–5.24	5; 3.73±0.13; 3.64–3.94
IFL	6; 6.50±0.49; 5.60–6.94	1; 5.18	6; 5.90±0.38; 5.40–6.50	5; 4.34±0.31; 3.98–4.70
ZP	5; 2.92±0.30; 2.56–3.30	1; 2.00	6; 3.07±0.15; 2.86–3.30	5; 2.41±0.09; 2.34–2.56
MANL	8; 14.01±0.67; 13.10–15.20	1; 12.14	10; 14.58±0.38; 14.04–15.30	8; 11.77±0.61; 10.90–12.94
MANTRL	9; 4.78±0.21; 4.52–5.20	1; 4.22	10; 4.91±0.21; 4.60–5.40	9; 3.78±0.22; 3.40–4.02

IOC, interorbital constriction; RW2, mid-rostral width; DL, diastema length; MTRL, maxillary toothrow length; IFL, incisive foramina length; ZP, breadth of zygomatic plate; MANL, mandibular length; MANTRL, mandibular toothrow length; n, sample size; x, mean; sd, standard deviation; r, range.

New records Santiago del Estero province – INTA ''La María'' Research Station, 1.2 km to the west of the station entrance, 72 m (CNP 2358). Tucumán province – approximately 4 km to the northwest of Las Cejas, 348 m (PEO-e 295); approximately 12 km to the east of Los Ralos, along route 303, 421 m (PEO-e 291).

Comments This species was previously known in the study area by only one record. The new localities recorded are the first for Santiago del Estero and Tucumán provinces, confirm the presence of the species in Chaco Seco environment, and are the easternmost in the study area. The specimen captured in ''La María'' has uniform coloration, with a yellowish-brown color and a well-contrasting belly. The chin has a few white hairs and the tail is sharply bi-colored. The skull has a short rostrum, deep zygomatic notches, a divergent and sharp-edged interorbital region, and broad zygomatic plates. The capsular projection of the mandible is well-developed, situated behind the sigmoid notch, and backward-oriented. Upper incisors are proodont and the M1 has a weakly developed anteromedian flexus (Figure 4). Morphology and measurements of the specimens recovered from owl pellets are comparable to values recorded for this species in the study area (Table 2).

Tribu Oryzomyini Vorontsov, 1959
Oligoryzomys cf. *O. flavescens* (Waterhouse, 1837)

Previously known distribution in NWA *Oligoryzomys flavescens* (or a type assigned to this taxon) has been described for many localities in Catamarca, Jujuy, Salta, and Tucumán provinces, mainly for the Yungas ecoregion but with some records for semi-arid habitats as well, always associated with watercourses, in Monte de Sierras y Bolsones and Chaco Seco (Mares et al. 1997, Díaz et al. 2000, Díaz and Barquez 2007, Jayat et al. 2008b).

New records Salta province – La Poma, 3 km to the east, 3268 m (PEO-e 199, 228). Tucumán province – approximately 4 km to the northwest of Las Cejas, 348 m (PEO-e 296).

Comments Known localities for this species in semi-arid environments are very scarce, with no more than 10 records, and with no records from elevations above 3100 m. Here, we add two localities from semi-arid habitats, one of them the highest known for the species in NWA. The measurements of the specimens recovered from owl pellets closely match the recorded values for *Oligoryzomys flavescens* (Table 2), having a comparatively narrow rostrum, a narrow zygomatic plate (with anterior border straight or slightly concave), and a narrow mesopterygoid fossa, all characters assignable to *O. flavescens* in NWA.

Tribu Phyllotini Vorontsov, 1959
Andalgalomys olrogi Williams and Mares, 1978

Previously known distribution in NWA Ten records from Monte de Sierras y Bolsones and Chaco Seco in Catamarca province (Olds et al. 1987, Olds 1988, Braun and Mares 1995, Mares and Braun 1996, Mares et al. 1997).

New records Catamarca province – southern entrance road to the city of Catamarca, along route 38, 483 m (PEO-e 194).

Comments This is the first record for a sigmodontine in the Capital department of Catamarca province and the easternmost record for *Andalgalomys olrogi* in the study area. This new record is also just the seventh for the species in Chaco Seco environments in Argentina. The examined material consists of a skull fragment and a mandible recovered from an owl pellet. This material was identified by its possession of many features characteristic of the species, including a posteriorly divergent and wedge-shaped interorbital region, concave anterior border of the zygomatic plate, deeply excavated lunar notch of the mandible, a small coronoid process, and a condyloid process narrower than the greatest width of the angular process (Figure 4).

Auliscomys sublimis (Thomas, 1900)

Previously known distribution in NWA Only three records in Jujuy province and one in Salta province (Mares et al. 1981, Ortiz et al. 2000, Cirignoli et al. 2001, Díaz and Barquez 2007), with two of these from the beginning of the 20th century (Thomas 1919a, 1921b, 1926).

New records Jujuy province – approximately 3 km to the south of Guairazul, 4100 m (PEO-e 307). Salta province – La Poma, 3 km to the east, 3268 m (PEO-e 234, 200).

Comments These records represent the first existing record for Cochinoca and La Poma departments and, at the same time, are the westernmost and southernmost for the species in NWA. Although very uncommon in the previously recorded localities, this species was dominant in the pellet samples from Guairazul. All of the specimens show backward-sloping zygomatic plates, grooved upper incisors, mandibles with relatively short masseteric crests, indistinct capsular projections, and robust coronoid and angular processes (Figure 4).

Calomys laucha (G. Fischer, 1814)

Previously known distribution in NWA Previously recorded in all of the provinces in NWA (Thomas 1913, Hershkovitz 1962, Massoia and Fornes 1965, Mares et al. 1981, Piciucchi de Fonollat 1984, Olds 1988, Ojeda and Mares 1989, Capllonch et al. 1997, Massoia et al. 1997, Piciucchi de Fonollat and Marigliano 1999, Díaz et al. 2000, Dragoo et al. 2003), but its presence was recently brought into question (Díaz et al. 2006).

New records Santiago del Estero – INTA ''La María'' Research Station, 1.2 km to the west of the station entrance, 72 m (CNP 2359). Tucumán province – intersection of national route 9 and Arroyo India Muerta, 658 m (CNP 2360).

Comments *Calomys laucha* was previously recorded for Santiago del Estero province by only two records (Massoia et al. 1997, Dragoo et al. 2003). The new records confirm the presence of this species in Chaco Serrano and Chaco Semiárido ecoregions for the south of the study area. The INTA ''La María'' record is also the first for Capital department. Both captured specimens are small, have well-developed white post-auricular patches and fur with a sharply defined white belly, and lack sharply contrasting dorsal and ventral coloration in the tails. Some diagnostic features of the skull and mandible were also present, including divergent sides of the supraorbital region and the extension of the anterior masseteric ridge to the dorsal edge of the mandible.

***Calomys lepidus* (Thomas, 1884)**

Previously known distribution in NWA No more than 10 records from Jujuy, Salta, and Tucumán provinces, all from above 2600 m (Thomas 1919a, Hershkovitz 1962, Espinosa et al. 1997, Ortiz et al. 2000, Cirignoli et al. 2001, Díaz and Barquez 2007, Ferro and Barquez 2008, Jayat et al. 2008b).

New records Catamarca province – Laguna Blanca, 3243 m (CNP 2361).

Comments This is the first record of the species from Catamarca province. This species seems to be uncommon in the Laguna Blanca area, where we collected only one specimen among 40 individuals of sigmodontines. The individual captured is small (99 mm in total body length), has long, soft fur and a very short tail (38 mm). Some diagnostic characteristics of the skull were also evident, including lack of backward divergence in the supraorbital region, which also had square rather than beaded edges.

***Calomys musculinus* (Thomas, 1913)**

Previously known distribution in NWA Many localities in Jujuy, Catamarca, and Tucumán provinces, always in open environments and in most of the ecoregions (Olds 1988, Mares et al. 1997, Díaz and Barquez 2007, Jayat et al. 2008b).

New records Salta province – approximately 4.5 km to the southwest of the southern boundary of Tin Tin, Los Cardones National Park, 3030 m (PEO-e 280, 284); La Poma, 3 km to the east, 3268 m (PEO-e 202, 230). Santiago del Estero province – INTA ''La María'' Research Station, 1.2 km to the west of the station entrance, 72 m (CNP 2362); INTA ''La María'' Research Station, 2.9 km to the W of the station entrance, 137 m (CNP 2363).

Comments We added two localities for Salta province and two for Santiago del Estero province, areas with few previously reported localities for this species (Massoia and Fornes 1965, Massoia 1987, Olds 1988, Díaz et al. 2000, Ortiz et al. 2000, Jayat et al. 2008b). These are the first records of *Calomys musculinus* in Cachi and La Poma departments in Salta, and from Capital department in Santiago del Estero. These new records also add a second for the species from Los Cardones National Park. All of the specimens captured in ''La María'' have a weakly developed whitish post-auricular patch, grayish-white belly with slate-colored hair bases, and clearly bi-colored tails.

***Graomys griseoflavus* (Waterhouse, 1837)**

Previously known distribution in NWA Initially recorded in all of the provinces and most of the ecoregions (Hershkovitz 1962, Massoia and Fornes 1965, Mares et al. 1981, 1997, Piciucchi de Fonollat 1984, Piciucchi de Fonollat et al. 1985, Massoia 1987, 1988, Olds et al. 1987, Massoia et al. 1997, Díaz et al. 2000, Ramirez et al. 2001, Díaz and Barquez 2007), but now considered to be restricted mainly to Monte las Sierras y Bolsones (Theiler and Blanco 1996, Lanzone et al. 2007, Ferro and Martínez 2009).

New records Salta province – approximately 4.5 km to the southwest of the southern boundary of Tin Tin, Los Cardones National Park, 3030 m (PEO-e 276, 281); La Poma, 3 km to the east, 3268 m (PEO-e 204, 232); Valle del Tonco, 2995 m (PEO-e 146).

Comments Here, we add the first record from La Poma Department. The localities of Tin Tin and Valle del Tonco are also the first records of this species for Los Cardones National Park. In fact, this species did not have any records from within the protected areas system of NWA. Skull fragments recovered from pellets show divergent supra-orbital regions with beaded edges (projected as ledges) and concave anterior zygomatic plate borders (with the upper corner projected as a short spine). Molars with flat cusps, triangular outlines, and a tendency for lamination were also present (Figure 4).

***Phyllotis xanthopygus* (Waterhouse, 1837)**

Previously known distribution in NWA Many records from Catamarca, Jujuy, Salta, and Tucumán provinces, mainly from open arid and semi-arid environments. Recorded localities also tend to be in areas with rocky outcrops above 1000 m elevation (Yepes 1933, Pearson 1958, Hershkovitz 1962, Mares et al. 1997, Kramer et al. 1999, Piciucchi de Fonollat and Marigliano 1999, Díaz et al. 2000, Albright 2004, Díaz and Barquez 2007, Jayat et al. 2007a, 2008b, Ferro et al. 2010), but there are also a few lower-elevation records (Pearson 1958, Hershkovitz 1962, Mares et al. 1997, Jayat et al. 2006, 2007a).

New records Jujuy province – approximately 1 km to the east of Olaroz Chico, 4060 m (PEO-e 309). Salta province – approximately 2 km to the southwest of the southern boundary of Salar de los Pastos Grandes, 3790 m (PEO-e 318); approximately 4.5 km to the southwest of the southern boundary of Tin Tin, Los Cardones National Park, 3030 m (PEO-e 277, 282, 286); approximately 16 km to the ENE of Mina La Casualidad, 4260 m (301); La Poma, 3 km to the

east, 3268 m (PEO-e 206, 233); Valle del Tonco, 2995 m (PEO-e 147).

Comments Here, we present the first records for La Poma department and Olaroz-Cauchari Provincial Reserve, and two new records for Los Cardones National Park, where the species was previously known from only one locality. The examined remains have characteristics typical of this species, including a long and slender rostrum, large posterolateral palatal pits situated well anterior of the anterior border of mesopterygoid fossa, and square interorbital edges.

Sigmodontinae insertae sedis *Andinomys edax* Thomas, 1902

Previously known distribution in NWA Mainly in the more humid eastern montane ranges in the region (on Cordillera Oriental, Sierras Centrales and northernmost Sierras Pampeanas), associated with high-altitude grasslands and ecotonal zones between 1500 and 4000 m in Yungas, Prepuna, Puna, and High Andean environments, but with some records in Yungas forest below 1000 m (Jayat et al. 2009a).

New records Jujuy province – approximately 3 km to the south of Guairazul, 4100 m (PEO-e 311). Salta province – Quebrada Alumbriojo, approximately 8 km to the northeast of Santa Ana, 2900 m (CNP 2364).

Comments In Salta province the records for this species are scarce, restricted to only five localities in the central and northernmost regions. Jayat et al. (2009a) recently added some new localities for NWA and generated a potential distribution map, which predicted the presence of *Andinomys edax* in large areas on the eastern slopes of the Santa Victoria and Zenta ranges, where there are not yet any actual records. Both new localities are inside the area considered as suitable based upon the climatic envelope developed for the potential distribution of the species (Jayat et al. 2009a), corroborating the presence of this species in the southern Santa Victoria range. The specimens from Guairazul were identified by their robust mandibles, with short and low masseteric crests, and their large, prismatic, and flat-crowned molars.

Neotomys ebriosus Thomas, 1894

Previously known distribution in NWA Only six records from Catamarca, Jujuy, and Salta provinces, always associated with open environments above 2600 m (Thomas 1921b, Barquez 1983, Díaz et al. 2000, Ortiz et al. 2000, Pardiñas and Ortiz 2001, Díaz and Barquez 2007, Jayat et al. 2008b).

New records Jujuy province – approximately 3 km to the south of Guairazul, 4100 m (PEO-e 310). Salta province – La Poma, 3 km to the east, 3268 m (PEO-e 205).

Comments These are the first records for the species from Cochinoca and La Poma departments. In Jujuy, the few previous records came from locations along the eastern border, but the new record confirms the presence of this species in the central-western Altiplano region of the province. Several striking features of the skull and mandible allowed the remains to be easily identified to this species, including a concave zygomatic plate with a well-developed zygomatic spine, a very deep and robust mandible, and strongly laminated molars with flat occlusal surfaces (Figure 4).

Discussion and conclusions

The geographical range of a species is the basic unit of biogeography (Brown et al. 1996, Davies et al. 2009), as well as a critical factor for understanding many other aspects of the biology of a species (Rosenzweig 1995, Brown and Lomolino 1998, Elith et al. 2006, Buermann et al. 2008). Many taxonomic decisions are also dependent on a sound knowledge of the geographical range of the taxa under consideration (Baker and Bradley 2006, Fitzpatrick and Turelli 2006). The affinities of particular species for different environments are also important on paleontological, ecological, and evolutionary grounds, as well as for conservation (Buermann et al. 2008, Alsos et al. 2009).

Studies regarding sigmodontine distribution in NWA have a long history, but only in recent times (from the mid-1990s onward) has this subject undergone more sustained development (Mares et al. 1997, Díaz et al. 2000, Ortiz et al. 2000, Jayat and Pacheco 2006, Díaz and Barquez 2007, Jayat et al. 2006, 2008b, 2009b, 2010). In spite of these more recent contributions, most of the accumulated knowledge for the region remains somewhat outdated (Thomas 1897, 1899, 1906, 1912, 1913, 1916, 1918, Yepes 1933, 1935, Sanborn 1947a,b) and does not involve NWA as the main area of interest (Pearson 1958, Olds et al. 1987, Spotorno et al. 1990, Steppan 1995, 1998, Anderson and Yates 2000, Salazar-Bravo et al. 2001, 2002, Hoffmann et al. 2002, Albright 2004). Furthermore, many reports contain few records and include only a narrow range of species (Massoia and Fornes 1967, Dalby and Mares 1974, Barquez 1976, 1983, Díaz et al. 1999, Steppan and Sullivan 2000, Ramirez et al. 2001, Lanzone et al. 2005, Barquez et al. 2006b, Ferro and Barquez 2008) or have not yet been critically evaluated (Thomas 1919b, 1921b, Massoia 1998). Finally, many contributions address the subject only peripherally (Bianchi et al. 1971, Mares 1975, Barquez et al. 1980, Ojeda 1980, Kajon et al. 1984, Vitullo et al. 1986, Liascovich et al. 1989, Blaustein et al. 1992, Apfelbaum et al. 1993, Abdala and Díaz 2000, Spotorno et al. 2001, Pini et al. 2003, Jayat and Miotti 2005). Our analysis of the literature also indicates that surveys are clearly biased towards areas located near the most important highways and, to a lesser extent, by proximity to the largest towns and cities in the region. Many gaps in reliable distributional information have therefore remained to be filled. There are very few occurrence records for Santiago del Estero province, and even many of the better-studied provinces have most of the localities concentrated in a handful of political departments (Catamarca representing an extreme example). From an environmental point of view, only certain

Table 3 Distribution of the new localities by ecoregion, protected areas, and altitude in the study area.

No. of locality	Ecoregion	Protected area	Altitude (m)
1	AA	–	4100
2	Y	RBY	2900
3	AA	RPOC	4060
4	P	PPLA	3790
5	P	–	3268
6	AA	–	4260
7	MSB	PNLC	3030
8	MSB	PNLC	2995
9	P	RBLB	3243
10	CHS	–	658
11	CHS	–	384
12	CHS	–	421
13	CHS	–	254
14	CHS	–	72
15	CHS	–	137
16	Y	–	1654
17	CHS	–	483
18	CHS	–	614

AA, Altos Andes; CHS, Chaco Seco; MSB, Montes de Sierras y Bolsones; P, Puna; Y, Yungas; PNLC, Los Cardones National Park; PPLA, Los Andes Provincial Park; RBLB, Laguna Blanca Biosphere Reserve; RBY, Yungas Biosphere Reserve; RPOC, Olaroz-Cauchari Provincial Floral and Faunal Reserve.

sectors of the Yungas ecoregion (Selva Pedemontana and Pastizales de Neblina altitudinal belts) have been relatively well surveyed. Vast areas of the high-altitude ecoregions (Altos Andes and Puna) are poorly studied, as is most of the Chaco Seco, the most widespread ecoregion in NWA. A distinctive geographical characteristic of NWA is its environmental diversity, with abrupt environmental changes taking place over remarkably short distances (up to four ecoregions can be found by traveling 150 km from east to west in some places). These circumstances establish several transitional areas practically unknown from the perspective of their sigmodontines populations (Figure 2C). Large areas of NWA are also characterized by the presence of mountain ranges, creating expansive areas of land with precipitous slopes. However, information recorded for areas with slopes steeper than 20% is meager. The picture created for sigmodontine distribution is also further biased because most surveys were carried out in relatively environmentally altered areas and anthropogenic environments, with studies of relatively pristine habitats virtually nonexistent.

As a consequence, there is a rather inadequate understanding of the distributions of most of the species represented in the region, with only a few concentrated efforts to establish their potential or real distributions (Jayat and Pacheco 2006, Jayat et al. 2009a). Many taxa typical of high altitudes (*Abrothrix jelskii* [Thomas], *Akodon boliviensis* Meyen, *Auliscomys sublimis* [Thomas], *Calomys lepidus* [Thomas], *Eligmodontia hirtipes* [Thomas], *E. puerulus* [Philippi], *Graomys edithae* Thomas, *Neotomys ebriosus* Thomas, *Phyllotis anitae* Jayat, D'Elía, Pardiñas and Namen, *Reithrodon auritus* [G. Fischer], *Tapecomys wolffsohni* [Thomas]), Chacoan environments (*Akodon dolores*, *Akodon toba* Thomas), and arid/semi-arid environments (*Andalgalomys olrogi*, *Eligmodontia bolsonensis* Mares, Braun, Coyner and Van Den Bussche, *Salinomys delicatus* Braun and Mares) are known from less than 15 records. Even species typical of relatively well-surveyed environments such as the Yungas ecoregion have scarce distributional information in our study area (*Akodon sylvanus* Thomas, *Oxymycterus akodontius* Thomas, *O. wayku* Jayat, D'Elía, Pardiñas, Miotti and Ortiz, *Phyllotis anitae*, *Rhipidomys austrinus* Thomas, *Tapecomys primus* Anderson and Yates).

Finally, there is uncertainty about which species of sigmodontines are well-preserved in protected areas. Many species (*Abrothrix jelskii*, *Akodon dolores*, *Akodon toba*, *Andalgalomys olrogi*, *Graomys edithae*, *Necromys amoenus* [Thomas], *N. lasiurus* [Lund], *Oxymycterus wayku*, *Phyllotis anitae*, *Reithrodon auritus*, *Salinomys delicatus*) have never been recorded in the national or international protected area systems.

In this report, we have added 18 new localities related to 14 sigmodontine species in our study area (Appendix II). These records mainly contribute information for Chaco Seco environments (localities 10–15, 17 and 18) and high-altitude locations in Puna (localities 4, 5 and 9) and Altos Andes (localities 1, 3 and 6) ecoregions, but also for Pastizales de Neblina of Yungas (localities 2 and 16) and Monte de Sierras y Bolsones environments (localities 7 and 8). Most of the localities are located above 3000 m elevation (localities 1, 3–7 and 9), and in other altitudinal belts for which previous records were largely lacking (localities 1, 3, 14 and 15). We have also added information for provinces (localities 13, 14 and 15 in Santiago del Estero) and species (*Akodon dolores*, *Andalgalomys olrogi*, *Calomys lepidus*, *Necromys lasiurus*, and *Neotomys ebriosus*) with very scarce previous records. Finally, we emphasize the new records located in protected areas including Yungas Biosphere Reserve, Olaroz Cauchari Provincial Reserve, Los Andes Provincial Park, Los Cardones National Park, and Laguna Blanca Biosphere Reserve (localities 2, 3, 4, 7, 8 and 9) (Table 3).

Although these new records are helpful, our knowledge of the geographical range for many sigmodontines in the region continues to be schematic. This became self-evident when we realized that 93% of NWA has no record at all. Because of this, appropriate characterization of these rodents for most of the environments in NWA is still lacking. To overcome this situation, it is necessary not only to improve our knowledge regarding distributions but also to resolve many of the taxonomic problems involving the regions of the species. Both of these aspects become more relevant in light of the accelerating human- and climate-induced changes to the landscape now occurring. Although sigmodontine rodents are usually not among the species taken into account for creation of conservation programs, they have traits related to biogeography (small and shrinking range distributions, poor dispersal capabilities), ecology (small population sizes during some annual periods), and evolution (speciation processes associated with exclusive habitat types, some unique lineages) that make them especially vulnerable to such changes

(Hannah et al. 2002, Davies et al. 2009). This situation seems even more critical in NWA, where fragmented habitats and strong physical and climatic gradients are predominant, which constitute important limiting factors related to species distributions (Bush 2002, Hannah et al. 2002).

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Appendix I

List of the species of Sigmodontinae rodents present in Northwestern Argentina

The list follows Barquez et al. 2006a with modifications that incorporate new taxonomic arrangement and distributional data (Barquez et al. 2006b, Jayat et al. 2007a, 2008a, 2010, D'Elía et al. 2008, Mares et al. 2008, Ferro and Martínez 2009).

Order Rodentia
Family Cricetidae
Subfamily Sigmodontinae
Tribe Abrotrichini
Abrothrix andina
Abrothrix illutea
Abrothrix jelskii
Tribe Akodontini
Akodon albiventer
Akodon boliviensis
Akodon budini
Akodon caenosus
Akodon dolores
Akodon fumeus
Akodon simulator
Akodon spegazzinii
Akodon sylvanus
Akodon toba
Necromys amoenus
Necromys lactens
Necromys lasiurus
Necromys sp.
Oxymycterus akodontius
Oxymycterus paramensis
Oxymycterus wayku
Tribe Oryzomyini
Euryoryzomys legatus
Holochilus chacarius
Oligoryzomys cf. O. flavescens
Oligoryzomys chacoensis
Oligoryzomys brendae
Tribe Phyllotini
Andalgalomys olrogi
Auliscomys sublimis
Calomys laucha
Calomys lepidus
Calomys musculinus
Calomys venustus
Calomys fecundus
Eligmodontia bolsonensis
Eligmodontia hirtipes
Eligmodontia moreni
Eligmodontia puerulus
Eligmodontia typus
Graomys chacoensis
Graomys domorum
Graomys edithae
Graomys griseoflavus
Phyllotis anitae
Phyllotis caprinus
Phyllotis osilae
Phyllotis xanthopygus
Salinomys delicatus
Tapecomys primus
Tapecomys wolffsohni
Tribe Reithrodontini
Reithrodon auritus
Tribe Thomasomyini
Rhipidomys austrinus
Sigmodontinae insertae sedis
Andinomys edax
Neotomys ebriosus

Appendix II

Gazetteer of new localities for sigmodontine rodents in Northwestern Argentina

- 3 km south of Las Juntas, 1654 m (Ambato, Catamarca) 28°8′7.9″S, 65°53′13.9″W (16).
- South access road for the city of Catamarca, along route 38, 483 m (Capital, Catamarca) 28°30′14″S, 65°46′54″W (17).
- Approximately 1 km to the east of Olaroz Chico, 4060 m (Susques, Jujuy) 23°23′37.2″S, 66°47′33.8″W (3).
- Approximately 2 km to the southwest of the southern boundary of the Salar de los Pastos Grandes, 3790 m (Los Andes, Salta) 24°39′7.6″S, 66°45′2.3″W (4).
- Approximately 3 km to the south of Guairazul, 4100 m (Rinconada, Jujuy) 22°56′45.2″S, 66°16′10.5″W (1).
- Approximately 4 km to the northwest of Las Cejas, 348 m (Cruz Alta, Tucumán) 26°51′38″S, 64°45′53″W (11).
- Approximately 4.5 km to the southwest of the southern boundary of Tin Tin, Los Cardones National Park, 3030 m (Cachi, Salta) 25°15′12″S, 65°59′59″W (7).
- Approximately 12 km to the east of Los Ralos, along route 303, 421 m (Cruz Alta, Tucumán) 26°52′39″S, 64°53′12″W (12).
- Approximately 16 km to the east-north-east of Mina La Casualidad, 4260 m (Los Andes, Salta) 24°57′33.8″S, 68°05′04″W (6).

- Approximately 30 km to the north of Pozo Hondo, along route 34, 254 m (Jiménez, Santiago del Estero) 26°54′05″S, 64°27′31″W (13).
- INTA ''La María'' Research Station, 1.2 km to the west of the station entrance, 72 m (Capital, Santiago del Estero) 28°1′28.5″S, 64°14′38.3″W (14).
- INTA ''La María'' Research Station, 2.9 km to the west of the station entrance, 137 m (Capital, Santiago del Estero) 28°1′41.5″S, 64°15′39.8″W (15).
- Intersection between national route 9 and the Arroyo India Muerta, 658 m (Trancas, Tucumán) 26°33′16.5″S, 65°16′44″W (10).
- La Poma, 3 km to the east, 3268 m (La Poma, Salta) 24°42′49.5″S, 66°09′58.5″W (5).
- Laguna Blanca, 3243 m (Belén, Catamarca) 26°32′S, 66°55′W (9).
- Quebrada Alumbriojo, approximately 8 km to the northeast of Santa Ana, 2900 m (Orán, Salta) 23°19′16″S, 64°55′3.7″W (2).
- Trampasacha, 614 m (Belén, Catamarca) 28°50′00″S, 66°18′21″W (18).
- Valle del Tonco, 2995 m (San Carlos, Salta) 25°23′22″S, 65°56′08″W (8).

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