Comunicaciones breves

SMALL MAMMALS IN PELLETS OF BIRDS OF PREY FROM A DESERT ECOTONE IN NORTHWESTERN PATAGONIA, ARGENTINA

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Abstract.- One of the distinctive features of the South American drylands is the presence of small mammals. This work presents the results of taphonomic and taxonomic analyses of micromammal (≤ 1 kg) bones recovered from an isolated deposit in pellets of birds of prey found in a cave located in the Neuquén province (Argentina). Taphonomic analyses revealed a low proportion of elements modified by digestion and of broken elements, as well as a relatively high abundance of post-cranial skeletal elements, a pattern suggesting that pellets were ejected by barn owls (*Tyto furcata*). Remains from members of five rodent genera (*Calomys, Eligmodontia, Phyllotis, Oligmodontia, Ctenomys*) were identified. The results of these analyses should contribute to ongoing ecological studies, especially on birds of pray, of Northwestern Patagonia.

Keywords: *skeletal remains, rodentia, strigiformes, taphonomy, drylands*

Resumen.- PEQUEÑOS MAMÍFEROS EN EGAGRÓPILAS DE AVES RAPACES EN UN ECOTONO DESÉRTICO DEL NOROESTE DE PATAGONIA, ARGENTINA. Uno de los rasgos distintivos de las tierras áridas sudamericanas es la composición de pequeños mamíferos. En este trabajo se presentan resultados tafonómicos y taxonómicos de restos óseos de micromamíferos (≤ 1 kg) recuperados de egagrópilas de aves rapaces encontradas en una caverna localizada en la provincia de Neuquén (Argentina). El análisis tafonómico reveló bajas proporciones de elementos modificados por la digestión y de elementos rotos como también abundancias relativamente altas de elementos esqueléticos, un patrón que sugiere que las egagrópilas fueron acumuladas por lechuzas de campanario (*Tyto furcata)*. Se identificaron restos de miembros de cinco géneros de roedores (*Calomys, Eligmodontia, Phyllotis, Oligmodontia, Ctenomys*). Los resultados de estos análisis deberían contribuir a los estudios ecológicos en curso, especialmente en aves de presa del noroeste de la Patagonia.

Palabras clave: restos óseos, rodentia, strigiformes, tafonomía, zonas áridas

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South America encompasses a diversity of arid habitats (i.e., drylands) occurring in tropical, highland, coastal, and continental biomes (Morello 1958). The small mammal fauna associated with these arid habitats varies widely with regard to taxonomic composition and species richness (Ojeda et al. 2000). One such biome, the Monte Desert, extends for over 2000 km in western Argentina, ranging from 24 to 4 degrees S (Brown and Pacheco 2006, Arana et al. 2021); this habitat, which covers an area of approximately 460 km^2, resembles parts of the North American Sonoran and Chihuahuan deserts. Daily temperature ranges from 27 to 7°C (Cabrera 1971), with annual precipitation typically being < 100-450 mm (Ojeda and Tabeni 2009). A second arid biome, the Patagonian Steppe is the 8th largest desert in the world, with a surface area of ca. 560 000 km^2 (Brown and Pacheco 2006, Murrie and Murrie 2010). Most of this cold desert, located in Argentina, receives less than 200 mm of precipitation per year (Paruelo et al. 1998), with daily temperatures ranging of 2 to 6°C in winter and 10 to 30°C in summer (Ojeda et al. 2000).

The small mammal communities in these arid habitats can differ markedly and these diverse landscapes are thought to be important factors in shaping the evolution of these communities (Ojeda et al. 2000). For example, although herbivores are the primary trophic level in both Monte Desert and Patagonian Steppe habitats, these two regions display marked differences in the associated assemblages of small mammals (Mares and Ojeda 1982). Importantly, arid ecosystems biomes have been characterized as having high levels of endemism of mammalian species (Mares 1992), suggesting that historical records of the small mammal communities in these habitats can be used as proxies to reconstruct paleoenvironmental conditions. Bird pellets are often a valuable source of modern and historical small mammal remains and thus provide an effective tool for inferring environmental conditions over multiple time scales (Pardiñas et al. 2012, Fernández et al. 2016a, Fernández et al. 2016b, Fernández and Pardiñas 2018, López et al. 2021b).

As part of efforts to understand the vertebrates communities in arid South American habitats, we analyzed bones and teeth from small mammals (≤ 1 kg) recovered from modern bird pellets collected from Caverna del León, Neuquén Province, Argentina. The goals of these analyses were to identify the likely source (predator species depositing pellets) and to characterize the taxonomic composition and species richness of the small mammals present in this deposit. These data, in turn, are used to draw inferences regarding environmental conditions in the vicinity of Caverna del León.

METHODS

Study area

Caverna del León (38°37’S, 70°13’ W, 1310 m.a.s.l.) is located at the interface between Monte Desert and Patagonian Steppe habitats in southwestern Argentina (Figure 1). The cave is located 20 km from the town of Las Lajas, in the center of Neuquén Province. The cave and surrounding area are used for multiple recreational activities, including visits by various speleological groups (Martinez 2018).

The approximate length of the cave is 852 m, with a maximum height of 24 m. The cave is composed of two large rooms, known as the “big room” and the “lake room”. The entrance to the cave follows a 40° slope (i.e., a dejection cone) that opens into the big room; a sub horizontal conduit exits the far end of this space, providing access to the lake room (Figure 1b), which contains a body of water approximately 50 m in diameter and 40 m deep. Several smaller galleries lead from the lake room to other portions of the cave complex (Tambor or Las Calizas room); additional details of the cave structure are provided in Barredo et al. (2012).

Data collection and analysis

Six bird pellets were recovered from the lake room of the cave complex during a speleological expedition conducted in December 2017. The predator depositing these pellets was not observed directly. The appearance of all pellets was consistent with

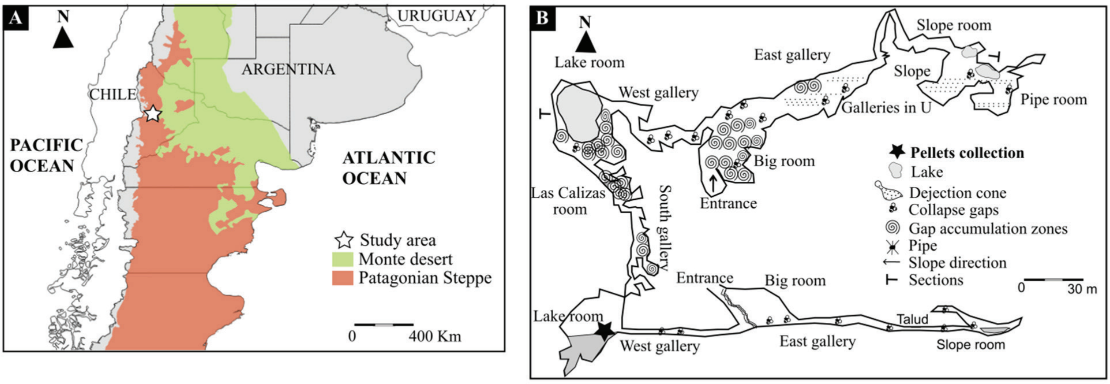

Figure 1. Study area and Caverna del León map shows a) location of study site in southern south America bordering Monte Desert and Patagonian Steppe ecorregions (Brown and Pacheco 2006), and b) Cavern structure (Tarquino-Carbonell and Turienzo 2019).

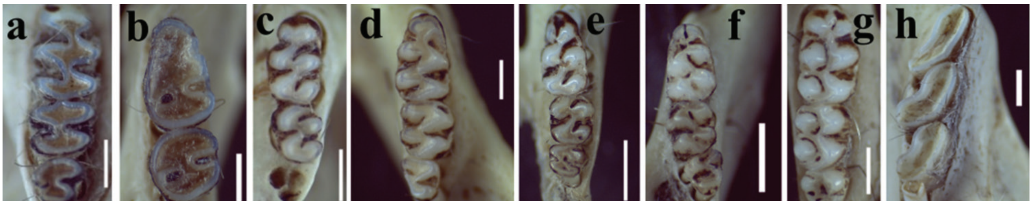

Figure 2. Cranial and tooth elements of the species found in Caverna del León, focused on molar series showing a) right upper molars of *Phyllotis pehuenche*, b) right lower molars of *P. pehuenche,* c) left upper molars of *Eligmodontia* sp., d) right lower molars of *Eligmodontia* sp., e) left upper molars of *Calomys musculinus*, f) left lower molars of *C. musculinus*, g) right upper molars of *Oligoryzomys longicaudatus,* h) right lower molars of *Ctenomys* sp. Occlusal view. Scale: 1 mm.

those of recently deposited samples. In the laboratory, the pellets were disaggregated with surgical instruments and all small mammal remains (teeth, bones) separated from other material contained in the pellets.

Taxonomic identifications were conducted by comparing small mammal remains with published descriptions and specimens housed in regional museum collections (CMI, Colección Mastozoológica IADIZA). Most such comparisons were based on cranial and dental material (Fernández et al. 2011, Patton et al. 2015), with materials isolated from pellets examined under a stereomicroscope (LEICA S6D; 6.3-40x) to facilitate identification of distinguishing characteristics. From these data, the number of identified specimens (NISP) and minimum number of individuals (MNI) were calculated (Lyman 2008). For taphonomic analyses, the relative abundance of skeletal (versus cranial) elements was examined, as were bone breakage patterns and evidence of digestive corrosion (Andrews 1990, Fernández et al. 2017). For each specimen, patterns of digestive corrosion on teeth (molars, incisors) and bones (femora, humeri) were classified as being light, moderate, heavy, or extreme based on the extent and intensity of the corrosion detected (Fernández et al. 2017, Montalvo et al 2016).

To evaluate the relationship between the abundance of different skeletal elements in living mammals and their representation in our sample, two taphonomic indices were employed. The first index calculated the relationship between cranial and postcranial elements (postcranial/ cranial, femora + humeri / mandible + maxillae); the second index measured the relationship between distal and proximal parts of the skeleton (tibiae+ radii/ femora + humeri). For both indices, the completeness of individual bones was evaluated separately for cranial and postcranial remains (Andrews 1990), after which the percentage of complete bones was calculated for both cranial elements and post-cranial long bones (i.e., femora). A principal components analysis was then used to determine which skeletal remains tended to cluster the relative abundances in our sample. Finally, tendencies of relative abundances were estimated. Both PCA and relative abundance analyses were conducted using the libraries stats and ggplot2 package in R (R Development Core Team 2020).

RESULTS

Based on bone and dental remains, total NISP for our sample was 320, with a MNI of 8. Five species of rodents were identified: *Calomys musculinus* (NISP = 2), *Eligmodontia* sp. (NISP = 5), *Oligoryzomys longicaudatus* (NISP = 3), *Phyllotis pehuenche* (NISP = 6) and *Ctenomys* sp (NISP = 2). Three of these taxa (*O. longicaudatus, Eligmondontia* sp., *P. pehuenche)* were each represented by a MNI= 2 (see Discussion). The remaining two taxa (*C. musculinus, Ctenomys* sp.) were each represented by MNI = 1. Taphonomic analyses revealed that almost no diagnostic elements exhibited digestive corrosion (Figure 3). The detected corrosion was typically characterized as light; only one element displayed moderate corrosion, with no examples of heavy or extreme digestion detected (Figure 3).

Principal component analysis included nocturnal and diurnal avian predators. Component 1 (54.33%) and 2 (22.53%) together accounted for 76.86% of the inertia (Figure 4). The hemimandibular/skull completeness and postcranial completeness were represented by percentages of 61.53% and 100%, respectively. The highest values of relative abundances of skeletal elements were represented by pelvis, tibiae and femora (Table 2). The pc/c index resulted considerable higher than 1 (3.31), indicating better representation of postcranial elements. The f+h/md+mx index (0.85) suggested a slightly better representation of cranial elements in comparison with postcranial ones. The value obtained for t+r/f+h index (1.18) showed a slightly better representation of distal parts in comparison to proximal elements of the skeleton.

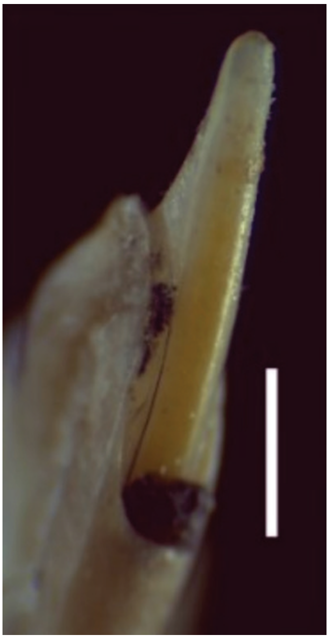

Figure 3. Digestion process, light digestion on Cricetidae incisor. Scale: 1 mm

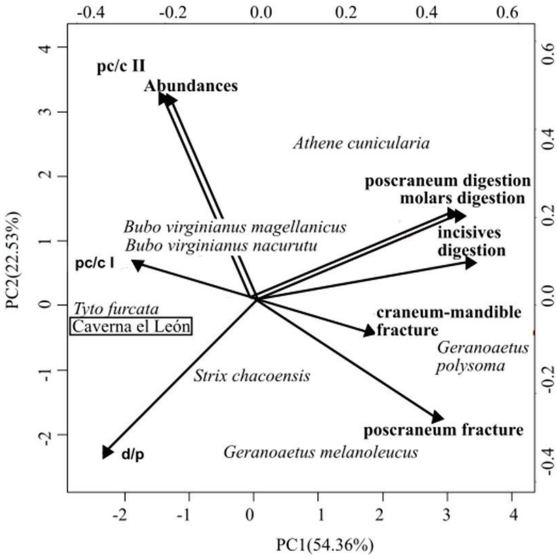

Figure 4. Principal component analysis including values reported in other birds of prey according to Montalvo and Fernández (2019) compared with this study.

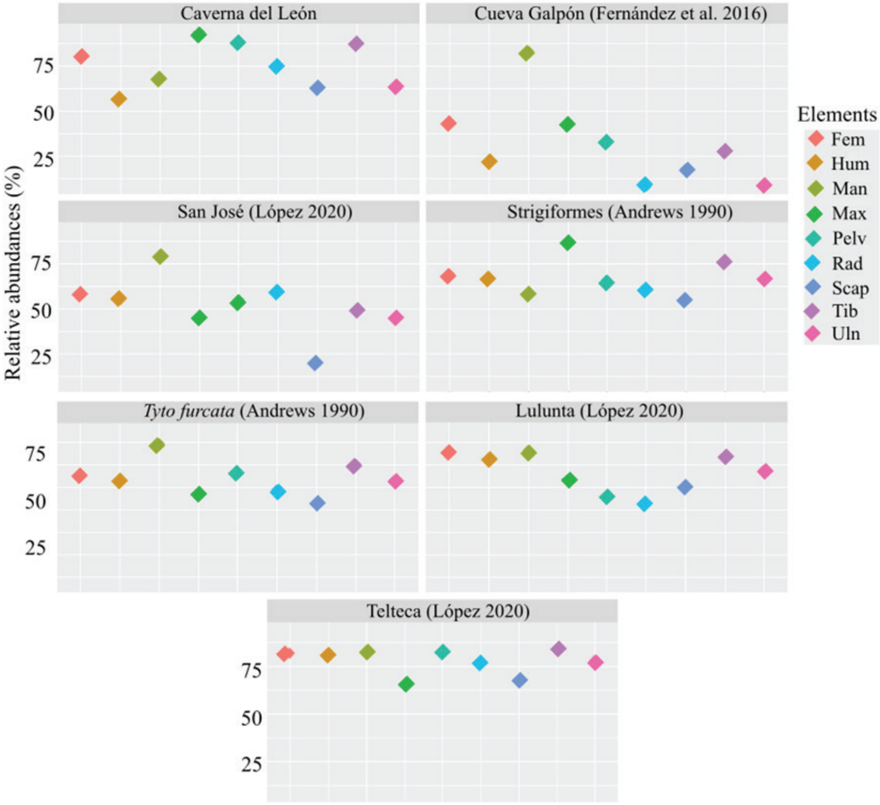

Figure 5. Relative abundances of elements according to Andrews (1990), Fernández et al. (2016b) and López (2020) compared with this study. Scap: scapulae. Fem: femurs. Hum: humeri. Mand: Mandibles. Max: Maxillae. Pel: Pelvis. Rad: Radii. Tib: Tibiae. Uln: Ulnae.

Table 1. Number and percentages of diagnostic elements modified by digestive corrosion indicated as absent (A), light (L), moderated (M), heavy (H) and extreme (E).

	A	%	L	%	M	%	H	%	E	%
Incisors in situ	20	76.92	5	19.23	1	3.85	0	0	0	0
Isolated incisors	2	100	0	0	0	0	0	0	0	0
Molars in situ	67	93.05	5	6.94	0	0	0	0	0	0
Isolated molars	2	100	0	0	0	0	0	0	0	0
Femora	11	84.61	2	15.38	0	0	0	0	0	0
Humeri	8	88.89	1	11.11	0	0	0	0	0	0

Table 2. Minimal number of elements (MNE), relative abundances (RA), number of identified specimens (NISP), broken elements and breakage percentages.

Element	MNE	RA (%)	NISP	n broken	Breakage (%)
Maxilae	15	93.75	15	9	60
Mandible	11	68.75	11	1	9.09
Scapulae	10	62.5	10	7	70
Humerii	9	56.25	9	0	0
Ulnae	10	62.5	10	0	0
Radii	12	75	12	0	0
Pelvis	14	87.5	14	0	0
Femurs	13	81.25	13	0	0
Tibiae	14	87.5	14	0	0

DISCUSSION

This study reports on the taxonomic composition and species richness of a small mammal community at the interface between Monte Desert and Patagonian Steppe habitats, as revealed by analyses of recently deposited bird pellets. No taxa distinctive to Monte Desert habitats were detected. In contrast, two of the species identified (*O. longicaudatus, P. pehuenche*) are considered typical of Patagonian Steppe habitats. The presence of *P. pehuenche* in our sample is particularly intriguing; this recently described species (Jayat et al. 2021) is thought to be endemic to northwestern portions of the Patagonian Steppe biome. Identification of *P. pehuenche* in our sample was based on morphological characters as well as geographic location. Morphologically, this species is distinguished by a skull that is not robust compared to other members of the genus, zygomatic arches that are comparatively not very expanded, and zygomatic notches that are narrower and less excavated than other species. The molar tooth row is longer but thinner than that in the *P. xanthopygus* complex. Additionally, the occlusal surface of the molars in *P. pehuenche* is more simplified, without the deep paraflexus on M2 or the mesoloph complex on M1 and/or M2 observed in *P. vaccarum* (Jayat et al. 2022). Geographically, *P. pehuenche* is the only member of this thought to occur in Neuquen Province. However, a recent taxonomic review revealed sympatry between this species and the *P. xanthopygus* complex in southern Mendoza, indicating that additional sampling in this region is needed to delimit more precisely the distributions of these species (Jayat et al. 2021, 2022).

Taphonomic implications

Similar findings regarding the relative abundance of post-cranial skeletal elements and the frequency of digestive corrosion have been reported for analyses of small mammal remains obtained from barn owl pellets recovered from Monte Desert habitat (López 2020). Owls generally swallow their prey whole, resulting in a high relative abundance of post-cranial skeletal elements and low frequencies of bone and tooth breakage (Andrews 1990). From a taphonomic perspective, predation by owls typically results in limited evidence of digestion of diagnostic elements (Andrews 1990). Barn owls have been implicated as the source of pellets containing small mammal remains in multiple studies from southern South America (Saavedra and Simonetti 1998, Pardiñas 1999, López and Chiavazza 2019, López 2020, Mignino et al. 2021), suggesting that barn owls are likely to be the primary source of pellets at sites from central western Argentina, including Caverna del León. Although other species of owls may also produce pellets containing small mammal remains, these species (i.e., *Athene cunicularia, Bubo magellanicus*) tend to produce remains that display greater evidence of damage and digestion than was detected during this study (Montalvo et al. 2016, Montalvo and Fernández 2019, López et al. 2021b). In contrast, the high relative abundance of post-cranial skeletal elements in our sample resembles reports for other analyses of pellets produced by barn owls (Andrews 1990). Thus, the results of our taphonomic analyses suggest pellets at Caverna del León were deposited by members of the Strigiformes, with barn owls (*Tyto furcata)* being a particularly likely contributor to our sample (López 2020).

Our conclusion that the pellets obtained from Caverna del León were deposited by owls is similar to findings from other sites located in the Monte Desert-Patagonian Steppe ecotone (Fernández et al. 2016b, López 2020). Accordingly, our findings add an important comparative data point to the growing number of studies that use bird pellets to characterize the small mammal communities at arid sites in South America. Although numerous studies have examined taphonomic patterns generated by different predators, differences have also been observed in the taphonomic trends generated by the same type of predator in different environmental regions, often associated with the size and availability of prey. Our findings have implications to strengthen environmental reconstructions in different taxonomic and taphonomic discussions.

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