Journal of Archaeological Science 52 (2014) 354–362

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Taphonomic analysis of rodent bone accumulations produced by the White-tailed Kite (*Elanus leucurus*, Accipitriformes) in Central Argentina

Claudia I. Montalvo [a, *], Fernando J. Fernández [b], M. Soledad Liébana [c, d], Miguel Santillán [c], José H. Sarasola [c, d]

[a] Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Uruguay 151, 6300 Santa Rosa, La Pampa, Argentina
[b] CONICET, Cátedra de Anatomía Comparada, Facultad de Ciencias Naturales y Museo, Street 64, Universidad Nacional de La Plata, 1900 La Plata, Buenos Aires, Argentina
[c] Centro para el Estudio y Conservación de las Aves Rapaces en Argentina (CECARA), Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Uruguay 151, 6300 Santa Rosa, La Pampa, Argentina
[d] Instituto de Ciencias de la Tierra y Ambientales de La Pampa (INCITAP)- CONICET, Uruguay 151, 6300 Santa Rosa, La Pampa, Argentina

ARTICLE INFO

Article history:
Received 12 June 2014
Received in revised form
1 September 2014
Accepted 3 September 2014
Available online 16 September 2014

Keywords:
Actualistic taphonomy
Rodent bones
Diurnal raptor
Accumulator agent
Accipitriformes
Elanus leucurus

ABSTRACT

The main objective of this study was to determine the taphonomic characteristics of ingested rodent prey remains recovered from White-tailed Kite (*Elanus leucurus*, Accipitriformes) pellets. Bones were analyzed in order to identify taphonomic features produced by this predator. Sampling was performed during the austral reproductive season of 2011 in Central Argentina (La Pampa province). The taphonomic variables evaluated suggest that *E. leucurus* produces strong digestion (categories 4–5). Results and interpretations were compared with results provided by samples from the Black-shouldered Kite, *Elanus caeruleus*, in Algelia, and from other Falconiformes and Accipitriformes species. The dietary similarity of *E. leucurus* and Barn Owl (*Tyto alba*, Strigiformes), suggests that both raptors are dietary counterparts, consuming the same trophic resources alternatively during day and night, but overlapping in their diets. In this context, the role of *E. leucurus* as fossil or archaeological bone accumulators or as an agent involved on the formation of the deposit might introduce an equifinality problem. The results presented here can be used as an analytical model for the interpretation of the micromammal fossil record from paleontological and archaeological sites.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

From a zooarchaeological and paleontological point of view, it is interesting to understand the processes and agents that take part in the formation of bone accumulations. In such context, taphonomic analysis is of prime importance. In archaeological and paleontological sites from Argentina, micrommamal remains are abundant, especially rodents (e.g., Pardiñas, 1999a, 1999b, 2004; Pardiñas et al., 2000; Fernández et al., 2009, 2012; Silveira et al., 2010; Fernández, 2012a, 2012b; Salemme et al., 2012). Taphonomic studies have recently been carried out to investigate the process of small vertebrate incorporation in the fossil record, including the accumulation and fossilization processes (Tonni et al., 1988; Pardiñas, 1996–1998; 1999a, 1999b; Gómez et al., 1999; Quintana, 2001, 2004; Quintana et al., 2002; Fernández, 2012a, 2012b; Fernández et al., 2012; Scheifler et al., 2012). Distinguishing small mammal bones accumulated by different agents such as diurnal raptors, owls, carnivore mammals, and humans is essential to carry out reliable palaeoenvironmental models based on these small faunal communities and for evaluating human subsistence vs natural action (Fernández, 2012a; and references therein). Predation produced by different agents could be characterized by distinct signatures, mainly anatomical element representation, breakage patterns, and the degree of digestion (Andrews, 1990).

Taphonomic studies on recent accumulations produced by different predators may contribute to establish their diagnostic characteristics (Andrews, 1990). Many predators that inhabit Argentina have already been evaluated in terms of the taphonomic modifications they produce on the bones of their prey (Álvarez et al., 2011; Ballejo et al., 2012; Carrera and Fernández, 2010;

* Corresponding author.
E-mail addresses: cmontalvo@exactas.unlpam.edu.ar, overlord@cpenet.com.ar (C.I. Montalvo).

http://dx.doi.org/10.1016/j.jas.2014.09.003
0305-4403/© 2014 Elsevier Ltd. All rights reserved.

Fernández, 2012a; Gómez, 2005, 2007; Gómez and Kaufmann, 2007; Martín and Borrero, 1997; Mondini, 1995, 2000, 2001, 2003, 2004; Mondini and Muñoz, 2008; Montalvo et al., 2007, 2008, 2012a; Montalvo and Tejerina, 2009; Pardiñas, 1999a, 1999b; Pardiñas et al., 2000; Rudzik et al., 2013). Particular taphonomic studies of remains produced by Falconiformes and Accipitriformes include the following species: Chimango Caracara (*Milvago chimango*; Gómez, 2007), Crested Caracara (*Caracara plancus*; Gómez, 2007; Montalvo and Tallade, 2009, 2010), Red-backed Hawk (*Buteo polyosoma*; Iglesias, 2009; Fernández, 2012a), Long-winged Harrier (*Circus buffoni*; Fernández, 2012a), and Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*; Fernández, 2012a).

The genus *Elanus* (Accipitriformes) includes four species of small diurnal raptors from Southern Asia, Africa, America, and Australasia (del Hoyo et al., 1999; Ferguson-Lees and Christie, 2001) which present numerous characteristics resembling owls: primary and secondary feathers have a velvety comb structure adapted for silent flight, zygodactylae, the presence of vibrissae around the beak, large frontally-placed eyes, and the shape and compaction of the pellets, among other similarities (Negro et al., 2006). Particularly *E. leucurus* and Barn Owl, *Tyto alba*, also present a high overlap of food-niches during breeding seasons (Scheibler, 2007).

E. leucurus ranges from southwestern United States in North America to central Patagonia in southern South America (Ferguson-Lees and Christie, 2001; Figueroa et al., 2006). This species occurs in a variety of open habitats with trees, and even increases its populations in disturbed habitats generated by human activities, such as agricultural practices (Warner and Rudd, 1975; Schlatter et al., 1980; Sarasola et al., 2007). In central Argentina and Chile, this medium-size raptor (300–360 g) nests and roosts mostly in trees or fence posts, and lives solitary during the resident season (winter) or in large colonies during the breeding season (summer) (Warner and Rudd, 1975; del Hoyo et al., 1999). This species is small-mammal consumer specialist, feeding upon a variety of rodent species, despite the fact that most diurnal raptors generally eat more small birds and insects (del Hoyo et al., 1999; and references therein). They can produce a variety of accumulations of pellets and non-ingested prey remains, mostly during the breeding season, and immediate composition. The diversity of consumed prey usually varies locally, according to the availability of accessible prey (Dunk, 1995), but *E. leucurus* may also specialize on the most energetically rewarding prey species available (Schlatter et al., 1980; Sarasola et al., 2007). In this sense, *E. leucurus* mostly hunt small cricetid rodents and tend to avoid larger-sized preys, possibly due to the difficulty of killing or handling the prey (Schlatter et al., 1980). Although the biology of this raptor has received little attention in the southern portion of its range, there are several studies on *E. leucurus* trophic habits and hunting behavior in Chile (Meserve, 1977; Schlatter et al., 1980; Jaksic et al., 1987; Mendelsohn and Jaksic, 1989; González-Acuña et al., 2009), Brazil (Scheibler, 2004, 2007) and Argentina (Leveau et al., 2002; Sarasola et al., 2007, 2010).

There is only one taphonomic study that evaluates prey bone modifications produced by a species of the genus *Elanus*, the Black-shouldered Kites, *Elanus caeruleus* (Souttou et al., 2012). The study was carried on a sample of 40 pellets in a farmland area of Algeria. The authors highlighted the taphonomic differences related to the taxa found in the evaluated remains. Most prey remains belonged to small mammals and the authors suggested that this diurnal raptor can be included among predators that produce strong modifications by digestion, allocating the species to categories 4–5 of Andrews (1990) (Souttou et al., 2012). These authors considered that the potential role of *E. caeruleus* as a small mammal bone accumulator must not be discarded in North-African archaeological and paleontological sites.

Based on the fact that *T. alba* is considered one of the most important micromammal accumulators (Saavedra and Simonetti, 1998), several small mammal remains from archaeological and paleontological sites of Argentina, and other parts of the world, have been attributed to this species (e.g. Andrews, 1990; Pardiñas, 1999a, 1999b, 2004; Pardiñas et al., 2000; Fernández et al., 2009, 2012; Silveira et al., 2010; Fernández, 2012a, 2012b). Despite this fact, which in general terms is suitable for cave sites, it is necessary to perform an extensive local actualistic taphonomic analysis of different raptor species in order to accurately interpret the origin of the micromammalian assemblages, including those recovered from open-air archaeological and paleontological sites. In this sense; other raptor birds, such as *Elanus*, which mainly feed on micromammals and produce significant accumulations of prey in open-air places, should also be considered as potential accumulators.

In this paper we present the results of a taphonomic analysis of the modifications produced by the *E. leucurus* on rodent prey bones recovered from pellets. The main goals were to compare the results obtained for this predator with data available from the literature concerning rodent bone modifications produced by *E. caeruleus* and other diurnal birds of prey; as well as provide new data that establishes criteria by which their role as fossil or archaeological bone accumulators, or as an agents involved in the formation of the deposit can be evaluated.

2. Materials and methods

A total of 118 pellets were collected below a nest and perches of a pair of *E. leucurus*, once a week during the reproductive season of 2011 (January and February). The nest was located in a small forest reserve of Caldén (*Prosopis caldenia*) in the Espinal biome of the semiarid pampas region of Argentina, near the city of Santa Rosa, La Pampa province (36°43′S, 64°16′W), (Fig. 1) (Cabrera, 1976). Currently, this area is surrounded by agricultural landscapes characterized by diverse land uses types, natural and cultivated pastures, and exotic tree plantations with remnants of native vegetation (Sarasola et al., 2007).

The average size of the pellets was about 5 cm in length by 3 cm wide. They were analyzed using standard techniques developed by Marti et al. (2007). Pellets were hydrated and broken apart by hand for the identification of prey remains. Small mammals were identified on the basis of skulls, mandibles, teeth, fur, and claws, using local reference collections (Chehébar and Martín, 1989; Pearson, 1995; Fernández, 2012a) as well as reference collections at the *Centro para el Estudio y Conservación de las Aves Rapaces en Argentina* (CECARA, UNLPam). Bones were observed under a Leica Ms5 binocular microscope, and some of them were photographed under a Jeol 35 CF SEM at 8 kV at the *Unidad de Administración Territorial* (UAT) of the Scientific and Technological Center CONICET Bahía Blanca (CCT CONICET- BB), in Bahía Blanca, Argentina.

From this sample, MNI (minimum number of individuals) and MNE (minimum number of elements) were calculated following the methodology described by Badgley (1986). The taphonomic analysis followed the methodology proposed by Andrews (1990) and Fernández-Jalvo and Andrews (1992). This methodology allows categorizing predators using the following characteristics:

1) Assessment of the relative abundance of skeletal elements considering the representation of each element in the context of the MNI: MNEi/(EixMNI) × 100, where MNEi is the minimum number of a given skeletal element in the sample and Ei is the expected number of that skeletal element in an individual.

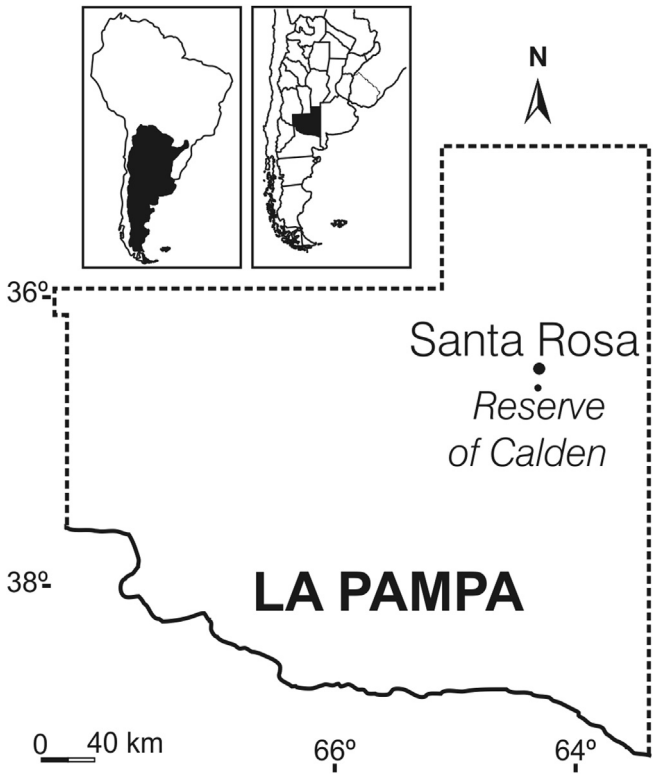


Fig. 1. Geographic location of sampling area in La Pampa province, Argentina.

2) Calculation of indexes for proportion of elements, (pc/c): [(femora + tibiae + humeri + radii + ulnae) × 8/(mandibles + maxillae + molars) × 5]; (f + h/md + mx): [(femora + humeri)/(mandibles + maxillae)]; (t + u/f + h): [(tibiae + ulnae)/(femora + humeri)], and (alv/m): [(mandibular alveoli + maxillary alveoli)/molars].
3) Evaluation of the degree of breakage, both for cranial and postcranial skeletal elements. Several categories were used to characterize the degree of completeness of the skull and mandible. Six categories were used for skull breakage: 1, complete skulls; 2, back of the broken skulls; 3, broken skulls without zygomatic region; 4, only maxillae and premaxillary; 5, isolated premaxillary; and 6, isolated maxillae. In all categories the molars retention was evaluated. Mandibles were assigned to one of five categories: 1, complete; 2, broken ascending ramus; 3, missing ascending ramus; 4, missing ascending ramus and symphysis; 5, symphysis with or without incisors. Postcranial bone elements were recorded as complete, proximal, diaphysis, or distal parts; the pelves and scapulae were recorded as complete or fragmented. Mean percentages of fragmentation [TNB total number of bones (=MNE); NBB number of broken bones; PF percentage of fragmentation = NBB/TNB] were calculated following Souttou et al. (2012).
4) Analysis of the degree of digestive corrosion was performed mainly on teeth (incisors and molars), proximal fragments of femora, and distal parts of humeri.

3. Results

3.1. Diet composition

E. leucurus pellets contained invertebrate remains such as grasshoppers (Orthoptera, Acrididae, 0.5%) and vertebrate bones (in particular sigmodontine rodents, 93%; cavies, 6%, and small amounts of birds, 0.5%). Only remains of rodent (sigmodontine and cavies) bones were evaluated in this paper.

Seven small mammal species were identified. Rodents constituted 99% of the prey items in terms of MNI. The Sigmodontinae (Cricetidae) rodents with the smallest sized were the most frequent taxa (ca. 71% of the sample) and include Vesper Mouse (*Calomys* sp.) and Gerbil Mouse (*Eligmodontia* sp.). In minor proportions, the sigmodontine rodents indentified include the Dolorous Grass Mouse (*Akodon dolores*), Azara's Grass Mouse (*Akodon azarae*), Gray Leaf-eared Mouse (*Graomys griseoflavus*), Bunny Rat (*Reithrodon auritus*), and the large-sized Caviidae rodent Common Yellow-toothed Cavy (*Galea leucoblephara*) (Table 1). Remains of larger rodents recovered in this sample were generally very fragmented. Although this prohibited the precise identification of the remains, all lager sized rodents were assigned to the *G. leucoblephara*, because this is the single Caviidae present in the study area.

3.2. Taphonomic analysis

3.2.1. Anatomical representation

From the total number of analyzed pellets, 2985 remains were recovered. This includes splinters, as well as any unidentifiable fragments, which were separated but not analyzed here (501 remains). The total MNE in the sample was 2484 skeletal elements. An MNI of 132 was calculated based on mandibles (*G. leucoblephara* MNI = 9 and Sigmodontinae rodents MNI = 123). This resulted in a relative average abundance of 28.78% (Table 2).

All the skeletal elements were represented in the *E. leucurus* pellets, the most frequent being Sigmodontinae bones. Skeletal element representation (Table 2; Fig. 2) showed that mandibles and maxillae were the most abundant (more than 90%); followed by the pelves and femora with averages between 43% and 60%, and lastly isolated incisors at 40%. Other anatomical elements had low values and skeletal element representation showed differences compared with representation found in other raptors (Fig. 2). The average skeletal representation including isolated teeth was similar to that observed for *E. caeruleus* (28%, Souttou et al., 2012) and other diurnal raptors (Andrews, 1990). In both cases, the mean value was very low, indicating an important loss of prey bones. Such representation was lower than that of a sample of *B. polyosoma* from Mendoza province (50.39%, Iglesias, 2009) and of *C. plancus* from La Pampa province (34.24%, Montalvo and Tallade, 2009).

Relative abundance of skeletal elements identified in the sample of *E. leucurus*, compared with data from *E. caeruleus*, *B. polyosoma* and *C. plancus* showed that maxillae and mandibles were well represented in the samples of *E. leucurus*, *E. caeruleus* and *B. polyosoma* (Fig. 2). Skeletal elements with more than 40% of representativeness found in the *E. caeruleus* sample included

Table 1
Diet composition of White-tailed kites, frequency of each taxon in the sample and estimated body masses according to data provided by Tiranti (1992) for rodent taxa present in the studied sample.

Taxa	F (%)	Body mass (g)
Calomys sp.	57.0	16
Eligmodontia sp.	14.5	17
Akodon dolores	9.0	38
Akodon azarae	3.5	22
Graomys griseoflavus	1.5	61
Reithrodon auritus	1.5	74
Unidentified Sigmodontinae	6.0	–
Galea leucoblephara	6.0	200
Unidentified Aves	0.5	–
Acrididae (Insecta)	0.5	–

Table 2
Number of skeletal elements and their relative abundance considering the MNI of 132.

	MNE	% Rel. Ab.
Mandibles	262	99.24
Maxillae	260	98.48
Scapulas	22	8.33
Humeri	58	21.97
Radii	29	10.98
Ulnae	48	18.18
Pelves	116	43,94
Femora	158	59.85
Tibiae	67	25.38
Vertebrae	543	11.43
Incisors	209	39.58
Molars	201	12.69
Metapodials	471	6.37
Calcanea	6	2.27
Astragali	2	0.76
Ribs	32	1.01

humeri, tibiae, and incisors; and in the *B. polyosoma* sample, humeri, ulnae, incisors, molars, and calcanea were recorded (Souttou et al., 2012; Iglesias, 2009). In contrast, in the sample of pellets of *C. plancus*, there was a lower representation of mandibles and maxillae, and the peaks corresponded to femora and metapodials (Montalvo and Tallade, 2009). The high frequency of cranial elements in the *E. leucurus* sample is one feature that differentiates this sample from those of *C. plancus*.

Several indexes were calculated (Table 3). The pc/c index showed deficiency of postcranial elements; f + h/md + mx index had low values and showed differences with respect to the postcranial elements. In this sense, and as it was pointed out before (Andrews, 1990; Gómez, 2007), most of the accumulations produced by Accipitriformes are characterized by a deficiency of postcranial elements, perhaps due to preferential destruction of these elements during consumption and digestion. The value obtained for the t + r/f + h index suggests an important loss of distal elements compared to proximal elements. Souttou et al. (2012) obtained similar results in the last two indexes when they were calculated over the remains of the two most frequent species in the sample of *E. caeruleus*. However, the value obtained for the pc/c index was higher, indicating better preservation of postcranial elements of their prey. Values of alv/mol index lower than 100 imply a loss of mandibles and maxillae. Negro et al. (2006) suggested that representatives of *Elanus* often ingest their small mammal prey whole, due to their large beak gape. The high number of isolated

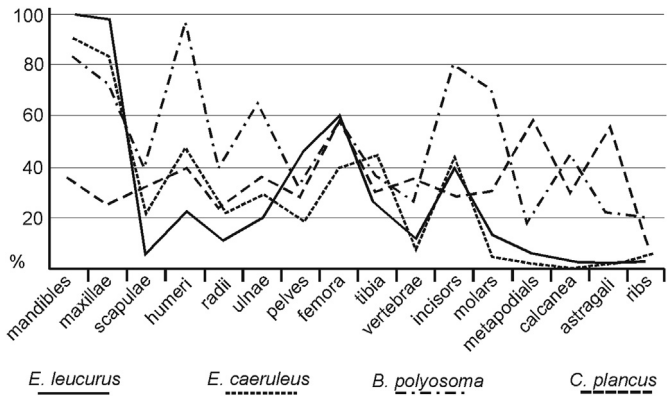


Fig. 2. Relative abundance of skeletal elements identified in the sample of White-tailed Kite (*Elanus leucurus*) compared with data from Black-Shouldered Kite (*E. caeruleus*), Red-backed Hawk (*Buteo polyosoma*) and Crested Caracara (*Caracara plancus*).

Table 3
Indexes calculated for the sample.

	Ratio
pc/c*8/5	79.67
(f + h)/(md + mx)	41.38
(t + r)/(f + h)	44.44
alv/mol	81.59

incisors was in agreement with skull breakage as previously suggested by Souttou et al. (2012) for *E. caeruleus*. Loss of mandibles and maxillae, however, may take place during prey handling, consumption, and digestion by *E. leucurus*, thus reducing the number of remains in the sample.

3.2.2. Breakage degree

From the total number of remains recovered from the pellets, 538 were skull portions (excluding isolated teeth). Among these, only incomplete skulls were found. This bias was similar to the one observed for *E. caeruleus*, where only one complete skull was recorded in the sample which could be explained by the fact that this skull belongs to *Mus spretus*, a very small rodent species in their sample, having probably been swallowed whole (Souttou et al., 2012). Maxillae with diverse degrees of fragmentation (categories 4 and 6) were frequent (Table 4), 3.5% of which lacked teeth as in the *E. caeruleus* sample (Souttou et al., 2012). More than 90% were sigmodontine isolated maxillae (Fig. 3a), 34.19% of them have 3 M *in situ*. Only one *G. leucoblephara* maxilla was found with 4 M and three with 3 M. We recovered 16 isolated premaxillaries, of which 31% had both incisors preserved. Only 10% of mandibles were complete (Table 4), this average was higher than for the *E. caeruleus* sample (Souttou et al., 2012). Category 3 (missing ascending ramus) was present in more than 47% of mandibles (Fig. 3b). All teeth were missing in 3.05% of the mandibles. It is noteworthy that, although the degree of breakage of maxillae and mandibles was high, fragments with molars *in situ* were well preserved, thus allowing taxonomic determination of these remains.

A total of 201 isolated molars were recovered from the sample and 9.95% of them were broken (mainly from *G. leucoblephara*), while the remaining molars were complete. The total sample comprised of 209 isolated incisors.

Postcranial elements from *G. leucoblephara* were scarce, always broken, and restricted to some vertebrae and metapodials.

Only 25% of sigmodontine postcranial elements evaluated for breakage degree (femur, tibia, humerus, ulna and radius) were complete. Distal humeral fragments, and proximal tibiae and femora were abundant. In the case of ulnae, complete bones predominated over other fragments (Table 5). Maxillae, scapulae and pelves were mainly broken (Table 6). Only pelves had a lower percentage of fragmentation when compared with data from *E. caeruleus* (Souttou et al., 2012) (Fig. 4). Complete metapodials and phalanges were also preserved in high proportion (only 10.83% were broken).

Scarce articulated parts of the autopodium as well as vertebrae were recovered (Fig. 5a).

In sum, *E. leucurus* produces a high degree of bone breakage. This bias is similar to that obtained by Souttou et al. (2012) for

Table 4
Proportion of skulls and mandibles in each evaluated category.

	cat.1	cat.2	cat.3	cat.4	cat.5	cat.6
Skull	0	0	1.52	7.58	0	90.91
Mandible	5.72	22.14	47.33	22.9	1.9	

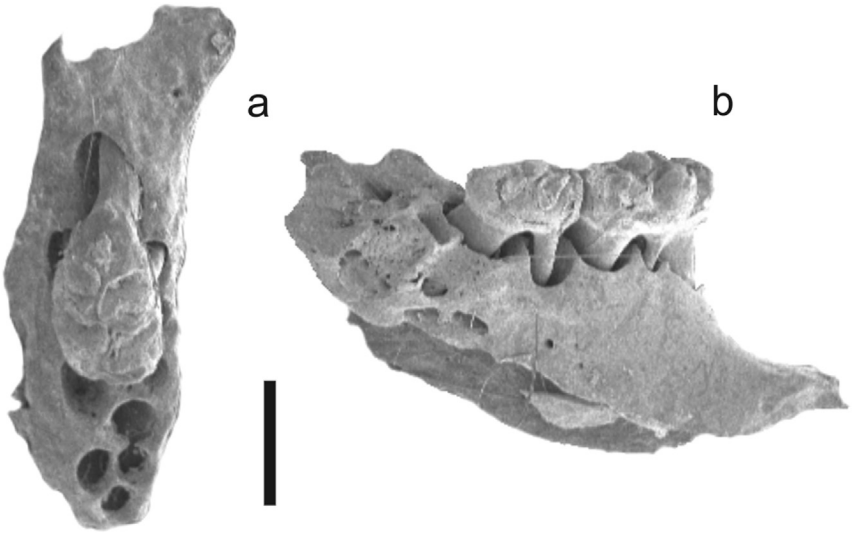


Fig. 3. a. Isolated maxilla of *Calomys* sp. (category 6); b. Mandible of *Calomys* sp. (category 4). Scale bar: 1 mm.

E. caeruleus, and Andrews (1990) for other diurnal raptors. Significant proportions of broken bones could be produced when raptor birds dismember their prey prior to ingestion (Andrews, 1990). Even so, there were cranial elements in this sample, such as observed for *C. plancus* (Montalvo and Tallade, 2009). Negro et al. (2006) indicated that large prey of *Elanus* are pulled apart, probably accounting for the scarce and broken postcranial remains assignable to the *G. leucoblephara*.

3.2.3. Digestion degree

Skeletal elements with some evidence of rounding and corrosion due to digestion were frequent (Fig. 5b–e). The skeletal elements evaluated for corrosion by digestive action showed some degree of modification (24% light, 35% moderate, 24% heavy, and 16% extreme) (Table 7). Souttou et al. (2012) indicated that light and moderate degrees of digestion were dominant in the *E. caeruleus* sample and extreme modifications were present in only a few remains. Differences were mainly in teeth modification and could be related with the size and tooth morphology of prey species because different rodent taxa do not always react identically to digestion (Demirel et al., 2011). Loss of bone material produced by digestive corrosion was very noticeable and in some cases the roots of the molars were exposed (Fig. 5d). Missing bone was also observed for *C. plancus* sample (Montalvo and Tallade, 2009). Several molars with heavy and extreme evidence of digestion showed occlusal surfaces with cracking and collapse of dentine, and others in which the enamel tended to separate from dentine at the enamel/dentine junction with the root. The highest percentage of incisors and molars with heavy and extreme modifications corresponded to isolated teeth, which may have been more exposed to the digestive action. Moderate modification in teeth was frequent in our sample (42.79%), similar to the one observed for *E. caeruleus* (Souttou et al., 2012).

Skeletal elements or bone fragments with other marks or grooves produced during predator-prey manipulation were not identified, but spiral fractures (*sensu* Marshall, 1989) were observed in several long bones.

4. Discussion

Taphonomic studies of bone remains accumulated by representatives of Accipitriformes have been performed for only a few species. Andrews (1990) assigned the Hen harrier (*Circus cyaeneus*), Common Buzzard (*Buteo buteo*) and Red Kite (*Milvus milvus*) to the categories 3–4 based on taphonomic modifications found on bones of prey. Gómez (2007) analyzed a sample from the *C. buffoni* and suggested that the species belongs to category 4; however, these results are based on a small sample size (only four pellets) that precludes further comparisons with other studies, including this one. Iglesias (2009) and Fernández (2012a) studied samples from *B. polyosoma*, also allocating this predator to category 4. Fernández (2012a) suggested that the *G. melanoleucus* produces strong values of corrosion and fracture in rodent bones. Souttou et al. (2012) evaluated the modifications produced by *E. caeruleus* on the prey bones using the same taphonomic methodology employed here. The authors of such study allocated the species to categories 4–5.

The different taphonomic attributes evaluated here for remains accumulated by *E. leucurus* (Table 8) were consistent with a strong predator modification category (type 4–5 predator) in the schemes proposed by Andrews (1990). Rodent bones of *E. leucurus* prey showed high values of bone destruction, breakage, and digestion similar to other diurnal raptors. These results were similar to those

Table 5
Breakage of postcranial elements in the sample.

	Femur		Humerus		Tibia		Ulna		Radius	
	MNE	%	MNE	%	MNE	%	MNE	%	MNE	%
Complete	22	13.92	21	36.21	9	13.43	21	43.75	17	58.62
Proximal	108	68.35	15	25.86	29	43.28	23	47.92	9	31.03
Distal	12	7.59	17	29.31	9	13.43	4	8.33	3	10.34
Shaft	16	10.13	5	8.62	20	29.85	0	0	0	0

Table 6
Number and percentage of fragmentation in cranial and postcranial elements (TNB: total number of bones; NBB: number of broken bones; PF: percentage of fragmentation = number of broken bones on total number of bones).

	TNB	NBB	PF
Maxilllae	260	260	100
Mandibles	262	247	94.30
Humeri	58	37	63.80
Femora	158	136	86.08
Scapulae	22	21	95.45
Ulnae	48	27	56.25
Radii	29	12	41.40
Pelves	116	104	89.65
Tibiae	67	58	86.57

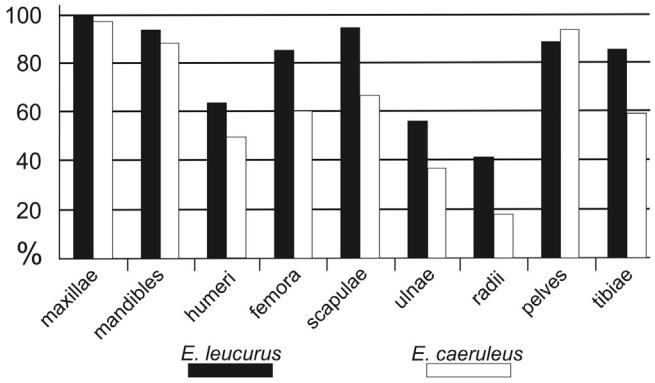


Fig. 4. Percentage of fragmentation (PF) of cranial and postcranial elements in the sample of White-tailed Kite (*Elanus leucurus*) compared with data from Black-Shouldered Kite (*E. caeruleus*).

obtained by Souttou et al. (2012) for *E. caeruleus*, but with higher proportion of bone breakage and slight differences in percentages of remains showing digestion modifications.

Bone assemblages produced by owls are characterized by an overall good anatomical representation; in other words, bones with little modifications and a high degree of completeness (Andrews, 1990). However, some differences have been described between fossil assemblages assigned to *T. alba* and data from actualistic evaluations. These are often attributed to postdepositional processes such as weathering, trampling, or other diagenetic changes (e.g. Pardiñas, 1996–1998; Pardiñas et al., 2000; Fernández et al., 2009, 2012); giving little importance to the possibility of diurnal raptor activities. In fact, after a detailed taphonomic revision of an earlier work, which assigned the microvertebrate assemblages to owl predation (Fernández, 2012a; Fernández et al., in press), only two archaeological sites from southwestern Mendoza Province with abundant microvertebrate remains were assigned to the activity of Accipitriformes, possibly *G. melanoleucus* or *B. polyosoma*.

Although *E. leucurus* and *T. alba* may select their prey in accordance to periods of prey activity, trophic overlap suggests potential competition for food (Leveau et al., 2004). Both raptors are dietary counterparts, consuming the same trophic resources alternatively during the day and night, with a high degree of overlapping in their diets, although *E. leucurus* from the humid Pampa feed mostly on sigmodontine rodents during the night (Leveau et al., 2004). Noteworthy, in coincidence with the results presented here, De Santis et al. (1983) pointed out that *Calomys* sp. and *Eligmodontia* sp. were the most frequent prey in a sample of *T. alba* pellets recovered from the study area, followed by *A. dolores*, *A. azarae* and *G. griseoflavus*. In this sense, the taxonomic composition and abundance of prey from both raptors can introduce an equifinality problem when attempting to define the origin of small mammal assemblages.

Table 7
Percentages of digestion in postcranial (proximal femur and distal humerus) and teeth (incisors and molars) within the sample.

	Total MNE	Light		Moderate		Heavy		Extreme	
		MNE	%	MNE	%	MNE	%	MNE	%
Femur	130	36	27.69	27	20.77	35	26.92	32	24.62
Humerus	38	7	18.42	10	26.32	7	18.42	14	36.84
Incisor *in situ*	221	29	13.12	45	20.36	68	30.77	79	35.75
Isolated incisor	209	5	2.39	30	14.35	84	40.19	90	43.06
Molar *in situ*	1096	325	29.65	451	41.15	238	21.72	82	7.48
Isolated molar	201	52	25.87	104	51.74	31	15.42	14	6.97

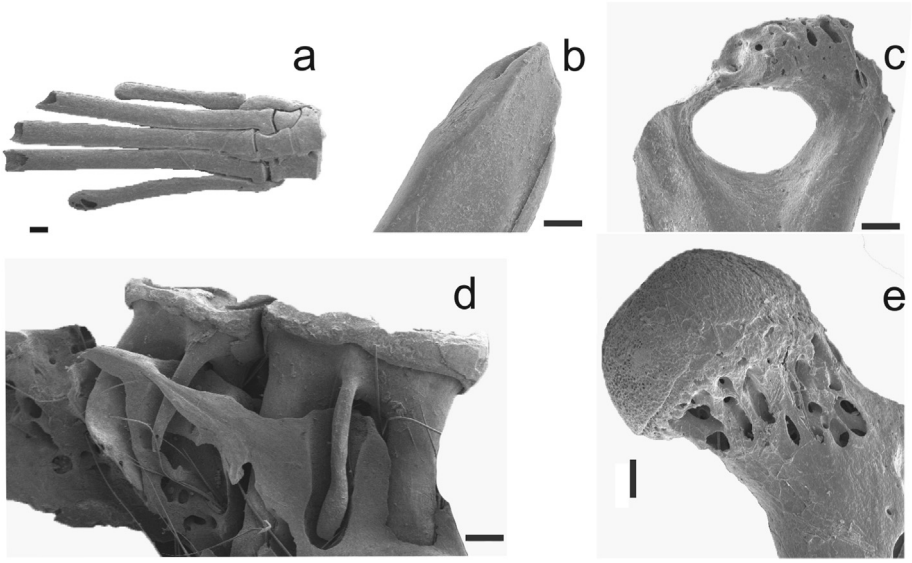
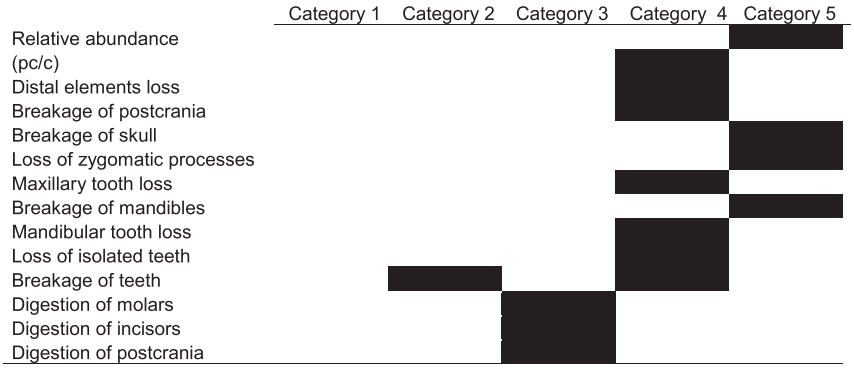


Fig. 5. Scanning electron microscope pictures showing articulated bones and digestion traces on rodent bones. a. articulated metapodials; b. incisor with heavy digestion; c. distal humerus with heavy digestion; d. mandible showing holes and missing bone, and molars with enamel separated from the dentine; e. proximal femur with heavy digestion. Scale bar: 200 μ.

Table 8
Categorization of the White-tailed Kite (*Elanus leucurus*) according to the analyzed variables.



The above issues reinforce the importance to evaluate the modifications produced by *E. leucurus* in small prey bones, and as a tool to recognize its role in the formation of archaeological or fossil accumulations. In this sense, several open-air archaeological and paleontological sites with micromammalian records exist in the breading area of *E. leucurus* (e.g., Gómez et al., 1999; Pardiñas, 1999a, 2004; Teta et al., 2004; Acosta and Pafundi, 2005; Silveira et al., 2010; Fernández et al., 2011; Fernández, 2012a, 2012b; Montalvo et al., 2012b; Salemme et al., 2012; Scheifler et al., 2012). Some of them were not taphonomically analyzed in detail, and presented abundant small sigmodontinae remains which might relate with *E. leucurus*, and therefore must take this data into consideration during future taphonomic revisions. For example, the micromammal record of the Divisadero Monte 6 archaeological site located along the coast of central-east Buenos Aires Province, in grassland environments, coastal brackish marshes a dense tala forest (*Celtis ehrenbergiana*), was taphonomically interpretated as a type of palimpsest (Silveira et al., 2010). It appears the large-sized micromammals were consumed by humans and the small-sized sigmodontinae were accumulated by *T. alba*, the last based on just a brief mention concerning the low degree of digestive corrosion in the sample (Silveira et al., 2010). In fact, a new scenario of different raptors, including *E. leucurus* could emerge when an extensive taphonomic study of this sample takes place. In another example, the small mammals of the Angostura 1 open-air archaeological site from lower Negro River basin at Río Negro Province were taphonomically associated to humans and Pumas (*Puma concolor*), the previous mainly due to the findings of the high levels of digestive marks and fragmentation in bone and teeth remains (Fernández et al., 2011). While the taphonomic analysis was exhaustive, according to similarities with the results presented here; it could take into consideration *E. leucurus* as a possible accumulator in future revisions.

5. Conclusions

The taphonomic evaluation shows that the *E. leucurus* may produce a substantial amount of bone destruction during prey consumption. Modifications in bone remains are consistent with a strong predator category (type 4–5 predator) in the schemes proposed by Andrews (1990). This result is similar to the one obtained by Souttou et al. (2012) for *E. caeruleus*, however, with higher proportion of bone breakage and slight differences in percentages of remains showing digestion modifications.

These differences can be attributed to particular behavioral traits of each *Elanus* species and also to the type of prey they consume. The studied sample highlights that, even with the strong modifications observed in the skeletal remains, both taxonomical and anatomical information can be retrieved from the consumed prey.

The dietary similarities between *T. alba* and *E. leucurus* might introduce an equifinality problem concerning taphonomical studies of micromammals. Therefore, it is important take into account the taphonomic features of the bone assemblages of *E. leucurus* in subsequent zooarchaeological analysis of small mammals, and in potential future revisions of published samples in order to recognize their role in the formation of fossil or archaeological accumulations.

In conclusion, the main taphonomic characteristics to associate micromammalian assemblages recovered from archaeological and paleontological open-air sites with *E. leucurus* as accumulator agents can be summed as follows: accumulations of micromammals with a dominance of smallest-sized sigmodontine rodents, a strong degree of digestive corrosion, a high breakage pattern, and a low average in relative abundance of skeletal elements with a better representation of maxillae, mandibles, pelves, femora, and isolated incisors.

This study contributes to the understanding of the taphonomy of South American diurnal raptors and may help to create models to interpret small mammal remains in archeological and paleontological faunal assemblages produced by different predators.

Acknowledgments

This work has been funded by Project 210 of the Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, and by the François Vuilleumier Fund for Research on Neotropical Birds (2010). Birders Exchange provided part of optical equipments. We also thank C. Deschamps and Daniel Rafuse for the English translation. Thanks are extended to the anonymous reviewers, and especially to P. Andrews and the editor R. Klein, which comments and suggestions have greatly improved this paper.

References

Acosta, A., Pafundi, L., 2005. Zooarqueología y tafonomía de *Cavia aperea* en el humedal del Paraná inferior. Intersecc. Antropol. 6, 59–74.
Álvarez, M.C., Kaufmann, C.A., Massigoge, A., Gutiérrez, M.A., Rafuse, D.J., Scheifler, N.A., González, M.E., 2011. Bone modification and destruction patterns of leporid carcasses by Geoffroy's cat (*Leopardus geoffroyi*): an experimental study. Quat. Int. 278, 71–80.
Andrews, P., 1990. Owls, Caves and Fossils. Predation, Preservation, and Accumulation of Small Mammal Bones in Caves, with the Analysis of the Pleistocene Cave Faunas from Westbury-sub-mendip, Somerset, UK. Natural History Museum Publications, London, 231 pp.

Badgley, C., 1986. Counting individuals in mammalian fossil assemblages from fluvial environments. Palaios 1, 328–338.
Ballejo, F., Fernández, F.J., De Santis, L.J.M., 2012. Tafonomía de restos óseos provenientes de egagrópilas de *Coragyps atratus* (jote de cabeza negra) en el noroeste de la Patagonia argentina. Rev. del Mus. Antropol. 5, 213–222.
Cabrera, A.L., 1976. Regiones fitogeográficas argentinas. In: Kugler, W.F. (Ed.), Enciclopedia Argentina de Agricultura y Jardinería, second ed. Editorial Acme, Buenos Aires. 85 pp.
Carrera, J.D., Fernández, F.J., 2010. Análisis tafonómico de egagrópilas producidas por el lechuzón orejudo (*Asio clamator*): un caso experimental. In: Gutiérrez, M.A., De Nigris, M., Fernández, P.M., Giardina, M., Gil, A., Izeta, A., Neme, G., Yacobaccio, H. (Eds.), Zooarqueología a principios del siglo XXI: aportes teóricos, metodológicos y casos de estudio. Ediciones del Espinillo, Buenos Aires, pp. 381–386.
Chehébar, C., Martín, S., 1989. Guía para el reconocimiento microscópico de los pelos de mamíferos de la Patagonia. Doñana. Acta Vertebr. 16, 247–291.
del Hoyo, J., Elliott, A., Sargatal, J., 1999. Handbook of the Birds of the World. In: New World Vultures to Guineafowl, vol. II. Lynx Editions, Barcelona, Spain, 638 pp.
Demirel, A., Andrews, P., Yalçınkaya, I., Ersoy, A., 2011. The taphonomy and palaeoenvironmental implications of the small mammals from Karain Cave, Turkey. J. Archaeol. Sci. 38, 3048–3059.
De Santis, L.J.M., Montalvo, C.I., y Justo, E., 1983. Mamíferos integrantes de la dieta de *Tyto alba* (Aves: Strigiformes, Tytonidae) en la provincia de La Pampa, Argentina. Hist. Nat. 21, 187–188.
Dunk, J.R., 1995. White-tailed kite (*Elanus leucurus*). In: Poole, A., Gill, F. (Eds.), The Birds of North America, No. 178. The Academy of Natural Sciences, Philadelphia, PA (The American Ornithologists' Union, Washington, DC U.S.A).
Ferguson-Lees, J., Christie, D.A., 2001. Raptors of the world. Christopher Helm, London, U.K.
Fernández, F.J., 2012a. Microvertebrados del Holoceno de sitios Arqueológicos en el sur de Mendoza (República Argentina): Aspectos Tafonómicos y Sus Implicancias en la Subsistencia Humana (PhD thesis). SEDICI, Universidad Nacional de La Plata, La Plata, 520 pp.
Fernández, F.J., 2012b. Tafonomía de microvertebrados exhumados del sitio arqueológico Agua de los Caballos-1 (Mendoza, Argentina). Comechingonia. Rev. Arqueol. 16, 169–174.
Fernández, F.J., Moreira, G.J., Neme, G.A., De Santis, L.J.M., 2009. Microvertebrados exhumados del sitio arqueológico «Cueva Arroyo Colorado» (Mendoza, Argentina): aspectos tafonómicos y significación paleoambiental. Archaeofauna 18, 99–118.
Fernández, F.J., del Papa, L., Moreira, G.J., Prates, L., De Santis, L.J.M., 2011. Small mammal remains recovered from two archaeological sites in the middle and lower Negro River valley (Late Holocene, Argentina): taphonomic issues and paleoenvironmental implications. Quat. Int. 245, 136–147.
Fernández, F.J., Teta, P., Barberena, R., Pardiñas, U.F.J., 2012. Small mammal remains from Cueva Huenul 1, northern Patagonia, Argentina: taphonomy and paleoenvironments since the Late Pleistocene. Quat. Int. 278, 22–31.
Fernández, F.J., De Santis, L.J.M., Neme, G.A., 2014. Micromammals, taphonomy, paleoenvironments and human occupation during the Holocene in Arroyo Malo-3 (west-central Argentina). Archaeofauna (in press).
Fernández-Jalvo, Y., Andrews, P., 1992. Small mammal taphonomy of Gran Dolina, Atapuerca (Burgos), Spain. J. Archaeol. Sci. 19, 407–428. dx.doi.org/10.1016/0305-4403(92)90058-B.
Figueroa, R.A., Corales, S., Figueroa, R., Mella, J., 2006. The most southern records of the White-tailed Kite (*Elanus leucurus*) in Patagonia. J. Raptor Res. 40, 176–177.
Gómez, G., 2005. Analysis of bone modifications of *Bubo virginianus*' pellets from Argentina. J. Taphon. 3, 1–16.
Gómez, G., 2007. Predators categorization based on taphonomic analysis of micromammals bones: a comparison to proposed models. In: Gutierrez, M.A., Miotti, L., Barrientos, G., Mengoni Goñalons, G., Salemme, M. (Eds.), Taphonomy and Zooarchaeology in Argentina, pp. 89–103. BAR S1601 (British Archaeological Report).
Gómez, G.N., Kaufmann, C.A., 2007. Taphonomic analysis of *Pseudalopex griseus* (Gray, 1837). Scat assemblages and their archaeological implications. J. Taphon. 5, 59–70.
Gómez, G., Prado, J., Alberdi, M., 1999. Micromamíferos del Sitio Arroyo Seco 2 (Provincia de Bs. As., Argentina), sus implicancias tafonómicas y paleoambientales. Estud. Geoló. 55, 273–281.
González-Acuña, D., Briones, E., Ardiles, K., Valenzuela-Dellarossa, G., Corales, S., Figueroa, R.A., 2009. Seasonal variation in the diet of the White-tailed Kite (*Elanus leucurus*) in a suburban area of southern Chile. J. Raptor Res. 43, 134–141.
Iglesias, A.C., 2009. Tafonomía de pequeños vertebrados depredados por *Buteo polyosoma* (Aves, Falconiformes). Licentiate Dissertation. Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa.
Jaksic, F.M., Rozzi, R., Labra, A., Jiménez, J.E., 1987. The hunting behavior of Black-Shouldered Kites (*Elanus caeruleus leucurus*) in central Chile. Condor 89, 907–911.
Leveau, L.M., Leveau, C.M., Pardiñas, U.F.J., 2002. Dieta del milano blanco (*Elanus leucurus*) en Argentina. Ornitol. Neotrop. 13, 307–311.
Leveau, L.M., Leveau, C.M., Pardiñas, U.F.J., 2004. Trophic relationships between White-tailed kites (*Elanus leucurus*) and Barn owls (*Tyto alba*) in southern Buenos Aires Province, Argentina. J. Raptor Res. 38, 178–181.
Marshall, L., 1989. Bone modification and "The laws of burial". In: Bonnichsen, R., Sorg, M. (Eds.), Bone Modification. Institute for Quaternary Studies, University of Maine, Orono, pp. 7–24.
Marti, C., Bechard, M.J., Jaksic, F.M., 2007. Food habits. In: Bird, D.M., Bildstein, K.L. (Eds.), Raptor Research and Management Techniques. Hancock House Publishers, Blaine, WA U.S.A, pp. 129–151.
Martín, F.M., Borrero, L.A., 1997. A puma lair in Southern Patagonia: implications for the archaeological record. Curr. Anthropol. 38, 453–461.
Mendelsohn, J.M., Jaksic, F.M., 1989. Hunting behavior of Black-shouldered kites in the Americas, Europe, Africa and Australia. Ostrich 60, 1–12.
Meserve, P.L., 1977. Food habits of a White-tailed Kite population in central Chile. Condor 79, 263–265.
Mondini, N.M., 1995. Artiodactyl prey transport by foxes in Puna rock shelters. Curr. Anthropol. 36, 520–524.
Mondini, N.M., 2000. Tafonomía de abrigos rocosos de la Puna. Formación de conjuntos escatológicos por zorros y sus implicancias arqueológicas. Archaeofauna 9, 151–164.
Mondini, N.M., 2001. Taphonomic Action of Foxes in Puna Rockshelters: a Case Study in Antofagasta de la Sierra (Province of Catamarca, Argentina). In: Kuznar, L.A. (Ed.), Ethnoarchaeology of Andean South America. Contributions to Archaeological Method and Theory International Monographs in Prehistory, Ethnoarchaeological Series 4, Ann Arbor, pp. 266–295.
Mondini, N.M., 2003. Modificaciones Óseas por Carnívoros en la Puna Argentina. Una Mirada Desde el Presente a la Formación del Registro Arqueofaunístico. Mundo Antes, 3, pp. 87–108.
Mondini, N.M., 2004. Accumulation of small and large vertebrates by carnivores in Andean South America. In: Brugal, J.-P., Desse, J. (Eds.), Petits Animaux et Sociétés Humaines. Du Complément Alimentaire aux Ressources Utilitaires. Actes des XXIVèmes Rencontres Internationales d'Archéologie et d'Histoire d'Antibes Éditions APDCA, Antibes, pp. 513–517.
Mondini, N.M., Muñoz, S., 2008. Pumas as taphonomic agents: a comparative analysis of actualistic studies in the Neotropics. Quat. Int. 180, 52–62.
Montalvo, C.I., Pessino, M.E., González, V., 2007. Taphonomic analysis of remains of mammals eaten by pumas (*Puma concolor* Carnivora, Felidae) in central Argentina. J. Archaeol. Sci. 34, 2151–2160.
Montalvo, C.I., Pessino, M.E., Bagatto, F.C., 2008. Taphonomy of the bones of rodents consumed by Andean hog-nosed skunks (*Conepatus chinga*, Carnivora, Mephitidae) in central Argentina. J. Archaeol. Sci. 35, 1481–1488.
Montalvo, C.I., Bisceglia, S., Kin, M., Sosa, R.A., 2012a. Taphonomic analysis of rodent bone accumulations produced by Geoffroy's cat (*Leopardus geoffroyi*, Carnivora, Felidae) in Central Argentina. J. Archaeol. Sci. 39, 1933–1941.
Montalvo, C.I., Tomassini, R.L., Visconti, G., Tiranti, S.I., 2012b. Análisis tafonómico de micromamíferos del Pleistoceno superior del Quequén Salado, provincia de Buenos Aires, Argentina. Rev. Bras. Paleontol. 15, 345–358.
Montalvo, C.I., Tallade, P., 2009. Taphonomy of the accumulations produced by *Caracara plancus* (Falconidae). Analysis of prey remains and pellets. J. Taphon. 7, 235–248.
Montalvo, C.I., Tallade, P.O., 2010. Análisis tafonómico de restos no ingeridos de roedores presa de *Caracara plancus* (Aves, Falconidae). In: Gutiérrez, M.A., De Nigris, M., Fernández, P.M., Giardina, M., Gil, A., Izeta, A., Neme, G., Yacobaccio, H. (Eds.), Zooarqueología a Principios del siglo XXI: Aportes teóricos, Metodológicos y Casos de Estudio. Ediciones del Espinillo, Buenos Aires, pp. 419–428.
Montalvo, C.I., Tejerina, P., 2009. Análisis tafonómico de los huesos de anfibios y roedores depredados por *Athene cunicularia* (Strigiformes, Strigidae) en La Pampa, Argentina. In: Berón, M., Luna, L., Bonomo, M., Montalvo, C.I., Aranda, C., Carrera Aizpitarte, M. (Eds.), Mamül Mapu: Pasado y Presente desde la Arqueología Pampeana, Tomo 1, pp. 323–334.
Negro, J.J., Pertoldi, C., Randi, E., Ferrero, J.J., López-Caballero, J.M., Korpimäki, E., 2006. Convergent evolution of *Elanus* kites and the Owls. J. Raptor Res. 40, 222–225.
Pardiñas, U.F.J., 1996–1998. Roedores holocénicos del Sitio Casa de Piedra 5 (Santa Cruz, Argentina): tafonomía y paleoambientes. Palimpsesto, Rev. Arqueol. 5, 66–90.
Pardiñas, U.F.J., 1999a. Los roedores muroideos del Pleistoceno Tardío-Holoceno en la Región Pampeana (sector este) y Patagonia (República Argentina): Aspectos Taxonómicos, Importancia Bioestratigráficas y Significación Paleoambiental (Ph.D. dissertation). Facultad de Ciencias Naturales y Museo, Universidad Nacional La Plata.
Pardiñas, U.F.J., 1999b. Tafonomía de microvertebrados en yacimientos arqueológicos de Patagonia. Arqueología 9, 265–308.
Pardiñas, U.F.J., 2004. Roedores sigmodontinos (Mammalia: Rodentia: Cricetidae) y otros micromamíferos como indicadores de ambientes hacia el Ensenadense cuspidal en el sudeste de la provincia de Buenos Aires (Argentina). Ameghiniana 41, 437–450.
Pardiñas, U.F.J., Moreira, G.J., García Esponda, C.M., De Santis, L.J.M., 2000. Deterioro ambiental y micromamíferos durante el Holoceno en el nordeste de la estepa patagónica (Argentina). Rev. Chil. Hist. Nat. 73, 9–21.
Pearson, O., 1995. Annotated keys for identifying small mammals living or near Nahuel Huapi National Park or Lanín National Park, southern Argentina. Mastozool. Neotrop. 2, 99–148.
Quintana, C.A., 2001. Composición y cambios en la secuencia faunística. In: Mazzanti, D., Quintana, C. (Eds.), Cueva Tixi: Cazadores y Recolectores de las Sierras de Tandilia Oriental, Geología, Paleontología Y Zooarqueología, vol. 1. Universidad Nacional de Mar del Plata Publ. Esp., pp. 37–64, 1.

Quintana, C.A., 2004. Acumulaciones de restos óseos en reparos rocosos de las Sierras de Tandilia oriental. Argent. Estud. Geoló. 60, 37–47.
Quintana, C.A., Valverde y, F., Mazzanti, D.L., 2002. Roedores y lagartos como emergentes de la diversificación de la subsistencia durante el Holoceno tardío en sierras de la región Pampeana Argentina. Lat. Am. Antiq. 13, 455–473.
Rudzik, S.M., Fernández, F.J., Carrera, D.J.D., 2013. Taphonomic analysis of micromammal remains from Striped owl (*Pseudoscops clamator*) pellets in Northeastern buenos aires province, Argentina: implications for archaeological sites formation. Int. J. Osteoarchaeol. http://dx.doi.org/10.1002/oa.2327.
Saavedra, B., Simonetti, J.A., 1998. Small mammals taphonomy: intraspecific bone assemblage comprasion between South and North American Barn Owl, *Tyto alba*, populations. J. Archaeol. Sci. 25, 65–170.
Salemme, M., Escosteguy, P., Frontini, R., 2012. La fauna de porte menor en sitios arqueológicos de la región pampeana, Argentina. Agente disturbador vs. recurso económico. Archaeofauna 21, 153–185.
Sarasola, J.H., Santillán, M.A., Galmes, M.A., 2007. Comparison of food habits and prey selection of the White tailed Kite, *Elanus leucurus*, between natural and disturbed areas in central Argentina. Stud. Neotrop. Fauna Environ. 42, 85–91.
Sarasola, J.H., Solaro, C., Santillán, M.A., Galmes, M.A., 2010. Communal roosting behavior and winter diet of the White-tailed Kite (*Elanus leucurus*) in an agricultural habitat on the Argentine pampas. J. Raptor Res. 44, 202–207.
Scheibler, D.R., 2004. Geographic variation in the size of mammalian prey taken by White-tailed Kites in the Americas. J. Field Ornithol. 75, 218–222.
Scheibler, D.R., 2007. Food partitioning between breeding White tailed kites (*Elanus leucurus*; aves; Accipitridae) and barn owls (*Tyto alba*; aves; Tytonidae) in southern Brazil. Braz. J. Biol. 67, 65–71.
Scheifler, N., Teta, P., Pardiñas, U.F.J., 2012. Small mammals (Didelphimorphia and Rodentia) of the archaeological site Calera (Pampean region, buenos aires province, Argentina): taphonomic history and Late Holocene environments. Quat. Int. 278, 32–44.
Schlatter, R.P., Toro, B., Yañez, J.L., Jaksic, F.M., 1980. Prey of the White-tailed Kite in central Chile and its relation to the hunting habitat. Auk 97, 186–190.
Silveira, M., Teta, P., Aldazabal, V., Eugenio, E., 2010. La fauna menor en la subsistencia de los cazadores recolectores del sitio "El Divisadero Monte 6" (partido de General Lavalle, provincia de Buenos Aires). In: Gutiérrez, M., De Nigris, M., Fernández, P., Giardina, M., Gil, A., Izeta, A., Neme, G., Yacobaccio, H. (Eds.), Zooarqueología a Principios del siglo XXI. Aportes Teóricos, Metodológicos y casos de Estudio. Ediciones del Espinillo, Buenos Aires, pp. 575–581.
Souttou, K., Manaa, A., Stoetzel, E., Sekour, M., Hamani, A., Doumandji, S., Denys, C., 2012. Small mammal bone modifications in black- shouldered kite *Elanus caeruleus* pellets from Algeria: implications for archaeological sites. J. Taphon. 10, 1–19.
Teta, P., Loponte, D., Acosta, A., 2004. Sigmodontinos (Mammalia, Rodentia) del Holoceno tardío del nordeste de la provincia de Buenos Aires (Argentina). Mastozool. Neotrop. 11, 69–80.
Tiranti, S.I., 1992. Barn owl prey in southern La Pampa, Argentina. J. Raptor Res. 26, 89–92.
Tonni, E.P., Bargo, M.S., Prado, J.L., 1988. Los cambios ambientales en el Pleistoceno tardío y Holoceno del sudeste de la Provincia de Buenos Aires a través de una secuencia de mamíferos. Ameghiniana 25, 99–110.
Warner, J.S., Rudd, R.L., 1975. Hunting by the White-Tailed kite (*Elanus leucurus*). Condor 77, 226–230.