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SPECIAL ISSUE PAPER

Chaetophractus villosus: A Disturbing Agent for Archaeological Contexts

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ABSTRACT *Chaetophractus villosus* (Dasypodidae), a medium-sized armadillo with burrowing habits, is one of the natural agents whose activities play a major role in archaeological deposit disturbance in the Pampean Region in Argentina. This paper presents the results of a comparative analysis between the archaeological materials collected from 32 currently active burrows and the remains collected in the sedimentary matrix identified as burrow filling during excavations of El Guanaco Site 1, Sector 1. As a general tendency, it was possible to establish that *C. villosus* removes both lithic and faunal materials that are 3 cm long or less. As an exception, materials up to 7 cm long are displaced. The distribution observed during the excavation of currently active burrows indicates that materials concentrate around the burrows' entrances. Copyright © 2011 John Wiley & Sons, Ltd.

Key words: burrowing activity; *Chaetophractus villosus*; mounds; Pampean Region; site formation

Introduction

Research on site formation processes is an essential instance of archaeological research because our interpretation of contexts heavily relies on the natural or cultural origin of the recovered remains. Actualistic studies allow archaeologists to gather relevant data about those processes by drawing analogies between past and present events, where past circumstances are inferred from analogical present situations (Binford, 1981; Gifford-Gonzalez, 1991).

Burrowing mammals are one of the different bioturbation agents that affect archaeological contexts. Their activity leads to the displacement of archaeological materials vertically and horizontally, the destruction of fragile remains and the obliteration of soil horizons (Wood & Johnson, 1978; Erlandson, 1984; Bocek, 1986; Politis & Madrid, 1988; Johnson, 1989; Wilkins, 1989; Durán, 1991; Bocek, 1992; Pierce, 1992; Mello Araujo & Marcelino, 2003; Fowler *et al*., 2004). There are two types of animals with burrowing habits: fossorial species, which spend most of their life underground, and those with a semi-fossorial lifestyle, which use burrows for different purposes (shelter, nesting, hibernation or birthing) but spend most of their time on the surface (Wilkins, 1989).

Although armadillos (Dasypodidae) are key taphonomic agents, the impact of their activities on archaeological sites has not been extensively analysed. A significant progress on this topic is Mello Araujo and Marcelino's (2003) experimental research on the habits of *Euphractus sexcintus*. These authors concluded that armadillos move different materials both vertically and horizontally and can also mix cultural horizons originally located at a distance of 20 cm from each other. In addition, some actualistic studies showed the inclusion of diverse materials into archaeological deposits due to the recolonisation of old armadillo galleries by rodents, anurans, owls, lizards and hares, which incorporate bones to the archaeological record as a result of the various feeding and reproduction habits and the patterns of behaviour of each such species (Frontini & Deschamps, 2007).

This paper aims to present the results of an actualistic study carried out on sediments accumulated in the entrances of current *Chaetophractus villosus* burrows found

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near archaeological sites in the south of Buenos Aires Province (Argentina). By digging, this species builds mounds at the entrance of its galleries. In archaeological areas, these mounds usually contain cultural remains that are often considered by archaeologists as a sign of buried archaeological strata (Mello Araujo & Marcelino, 2003).

Five species of Dasypodidae currently inhabit the Pampean Region (Argentina): *Dasypus hybridus*, *Tolypeutes matacus*, *Zaedyus pichiy*, *Chaetophractus vellerosus* and *Chaetophractus villosus* (Vizcaíno *et al.*, 1995). Several archaeological sites in the region have been affected by Dasypodidae activity (Bayón *et al.*, 2004; Frontini & Deschamps, 2007; Massigoge, 2007). Site 1, Sector 1 of El Guanaco archaeological locality (EG1 S1), located south of the Buenos Aires' Interserrana Area (Pampean Region, Argentina), is one of the sites disturbed by Dasypodidae actions. During site excavations, *C. villosus* galleries were identified running across the archaeological deposits.

The purposes of this article are (1) to analyse the kind of materials collected from currently active burrows; (2) to determine the size and degree of conservation of the removed material; (3) to compare actualistic findings with the materials recovered from the sedimentary matrix identified as burrow filling during excavations at El Guanaco Site 1 Sector 1; and (4) to generate archaeological expectations about the distribution of the removed material in order to recognise burrowing activities during site excavations.

Chaetophractus villosus: characteristics, distribution and behaviour

Chaetophractus villosus is a South American fossorial mammal from the order Edentata. Like all the other species in the Dasypodidae family, its body and head are heavily armoured with thick bony fixed and mobile plates arranged in transverse lines. It also has a long tail covered with bony plates (Cabrera & Yepes, 1940). It is widely spread across the Americas, from the Gran Chaco in Bolivia, Paraguay, and northern Argentina to Santa Cruz Province and, in Chile, from Valparaíso and the south of Bio Bio regions to Magallanes (Gardner, 2007). This mammal lives in open areas and is highly adaptive to semidesert conditions (Nowak & Paradiso, 1983; Vizcaíno & Milne, 2002). An adult weighs approximately 2.5 kg. It is mainly a nocturnal animal with an omnivorous diet that includes roots, insects, carrion, bird eggs and chicks (Redford, 1985; Abba *et al.*, 2010).

This armadillo is considered a powerful and fast digger owing to the long sharp claws on its forefeet and back feet, which are well adapted for this activity (Vizcaíno & Milne, 2002). It builds characteristic burrows that allow to easily identify the species (Abba *et al.*, 2005). These burrows have elliptical 15- to 20-cm-wide entrances, where the deposits removed during digging accumulate, creating mounds. Burrows may be simple or complex, depending on their function (Abba *et al.*, 2005). Simple burrows are built to obtain certain types of food (usually annelids and larvae) and to escape from predators. They have an average length of 70 cm and a maximum depth of 50 cm, and their structure consists in a single branch that descends obliquely from the ground surface. Burrows are usually located in sediments with a high content of moisture and organic components. In turn, complex burrows are used for living and nesting; they reach a maximum length of 4 m, with an average depth of 1 m. This type of burrow also slopes down in an oblique direction to a point where it becomes horizontal and finally bends at an angle of 90º. Complex burrows are built on hard soils with high lime content. Both types of burrows are dug in high places where floods do not occur, with their mouths facing away from the usual direction of the wind (Abba *et al.*, 2005).

Some of these characteristics allow to identify *C. villosus* burrows in archaeological contexts and to distinguish them from the ones belonging to other species. One of these features is the amount of entrances. While hairy armadillo burrows have a single entrance, *C. vellerosus* (small hairy armadillo) and *Dasypus hybridus* (mulita) caves have more than one entrance and galleries with several branches. Also, burrows of the latter species have grass accumulation on the entrance due to the species's particular behaviour (Abba *et al.*, 2005).

Another important characteristic is the width of *C. villosus* galleries. It is either smaller for other fossorial mammals in the area (i.e. *Ctenomys* sp.) or bigger (i.e. *Lagostomus maximus*).

Finally, the presence of claw markings in the gallery walls, especially those on hard soils, is another feature to identify these burrows. Nevertheless, this must be considered only as a complementary trait, as it is not always present (Frontini & Deschamps, 2007).

Materials and methods

Actualistic study

In order to test *C. villosus'* activity in diverse contexts, the documentation of 32 modern burrows was carried out in two archaeological localities: Paso Mayor and

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El Guanaco, situated in different environments (Figure 1). Eighteen burrows were documented at Paso Mayor and 14 at El Guanaco (EG) (Table 1).

Paso Mayor is an archaeological area that runs in the Southwest of the Province of Buenos Aires, in the South-eastern region of the Central Domain in zoogeographic terms (Ringuelet, 1961) and occupies the Southern District of the Espinal Province based on its phytogeography (Cabrera, 1968). It sits on a large sand dune on the left bank of the Sauce Grande River in the river valley. This dune originated as a result of the strong aridification processes that affected the area. It contains archaeological remains belonging to at least two settlement levels. The Lower Levels correspond to a base camp. Radiocarbon dates place the archaeological remains in the dune in middle Holocene: 5.877 ± 63 (AA-71656); 4.046 ± 57 (AA-82714); 3.820 ± 47 (AA-82709). The Upper Levels function first as a base camp during early late Holocene. A ^{14}C radiocarbon date obtained corresponded to 2.774 ± 45 (AA-91415); later, this place functioned as a burial area, at 700 ± 42 ^{14}C radiocarbon date (AA-56780) (Bayón *et al.*, 2010). At present, the dune is covered by weeping love grass that was intentionally planted. Numerous *C. villosus* burrows are currently distributed along the bottom, middle and top of the sand dune. The burrows surveyed were those located at the bottom of the extensive dune.

The archaeological locality of El Guanaco is situated in the Interserrana Area of Buenos Aires Province, surrounding the El Lucero lake, within the Pampean Domain from a zoogeographic perspective and the Southern District in phytogeographic terms. Two sites were excavated there: Site 1 and Site 2 (EG1 and EG2), located 500 m from each other (Zárate *et al.*, 2009; Flegenheimer *et al.*, 2010).

This area has a sedimentary matrix composed of Late Pleistocene-Holocene pedogenetically altered aeolian deposits. These two sites show differences attributable to their location along the landscape. EG1, which is situated on a plain, exhibits patterns that match zonal and regional profiles (Bayón *et al.*, 2004; Zárate *et al.*, 2009). EG2 is located on the east–northeast bank of the lagoon, over aeolian deposits that build up into a dune as a result of the deflation of the lagoon's basin. The actualistic research was performed at Site 2, whereas the application of the results was performed on Site 1.

Field methods consisted in recording the length and width of the mouth and the orientation of the burrows and collecting sediments at the entrances of the burrows. These sediments were screened in a 1-mm mesh, and their volume was estimated. Remains from each burrow were collected in separate bags. They were then cleaned, labelled, measured and analysed in the laboratory. These remains were classified according to the type of material (bone, lithic, pottery, industrial materials) and then assigned as being of archaeological, modern or indeterminable origin. Bones were anatomically and taxonomically identified. Those remains that were determined to be archaeological were the ones belonging to species that do not inhabit the area nowadays but are recovered in the area's archaeofaunal records. Lithic remains were classified according to their typology and raw materials. Remains that could not be assigned to a particular period were registered as indeterminable. This was the case with faunal remains from species that still live in the area, such as armadillos and birds, but are also present in archaeological contexts, being impossible to determine whether they are modern or past materials until radiocarbon studies are made.

Case study: El Guanaco 1 archaeological site

El Guanaco Site 1 Sector 1 (EG1 S1) is a multi-component site that was occupied from the Early Holocene to the Late Holocene (Bayón *et al.*, 2004; Zárate *et al.*, 2009).

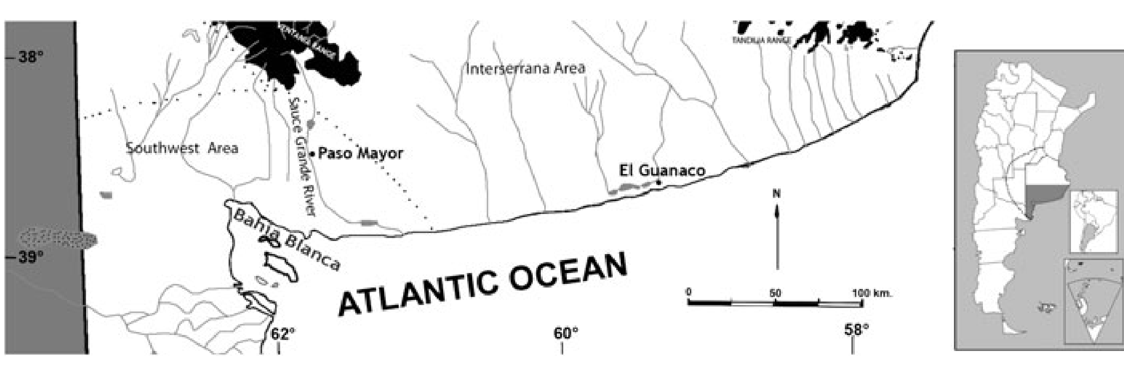

Figure 1. Localization of the localities studied.

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Table 1. Modern *Chaetophractus villosus* burrows surveyed

Burrow No.	Location	Opening		Orientation	Sediment		Presence of materials
		Width (cm)	Length (cm)		Kind	Quantity (m^3)	
1	EG2	20	18	N	$CaCO_3$	Absent	Absent
2	EG2	19	20	N	$CaCO_3$	Absent	Absent
3	EG2	18	20	N	$CaCO_3$	Absent	Absent
4	EG2	20	22	N	$CaCO_3$	64	Yes
5	EG2	26	20	N	$CaCO_3$	64	Yes
6	EG2	20	10	N	$CaCO_3$	64	Yes
7	EG2	22	18	N	$CaCO_3$	64	Yes
8	EG2	20	21	W	Organic Matter	8	Yes
9	EG2	20	26	E	Organic Matter	8	Yes
10	EG2	22	24	SE	Organic Matter	32	Yes
11	EG2	17	21	S	$CaCO_3$	8	Yes
12	EG2	20	22	W	Organic Matter	16	Absent
13	EG2	18	22	W	Sand	12	Yes
14	EG2	15	21	S	Sand	56	Yes
15	PM	18	20	N	Sand	24	Yes
16	PM	20	17	NE	Sand	12	Yes
17	PM	16	18	SW	Sand	8	Yes
18	PM	20	20	NW	Sand	28	Yes
19	PM	16	15	W	Sand	8	Yes
20	PM	19	17	E	Sand	Absent	Absent
21	PM	20	18	S	Sand	4	Yes
22	PM	18	19	W	Sand	16	Yes
23	PM	20	20	W	Sand	8	Yes
24	PM	20	20	W	Sand	8	Yes
25	PM	23	17	N	Sand	16	Yes
26	PM	26	17	W	Sand	18	Yes
27	PM	16	17	W	Sand	16	Yes
28	PM	15	18	W	Sand	4	Yes
29	PM	20	21	SW	Sand	8	Yes
30	PM	20	10	W	Sand	16	Yes
31	PM	28	20	E	Sand	16	Yes
32	PM	20	20	W	Sand	8	Yes

PM, Paso Mayor; EG2, El Guanaco Site 2.

Its profile has three stratigraphic units (Bayón *et al.*, 2004), the lowest being a calcium carbonate layer, which was the floor during the first human occupations. Unit 2 corresponds to a loess deposit with weak pedologic modification. A radiocarbon date has placed the upper levels of unit 2 in middle-Holocene times (Zárate *et al.*, 2009). The lowest levels of unit 2 included faunal remains of *Lama guanicoe*, *Lagostomus maximus*, *Lycalopex* sp., *Lutreolina crassicaudata*, *Ctenomys* sp., cavids and two extinct species, *Equus* sp. and

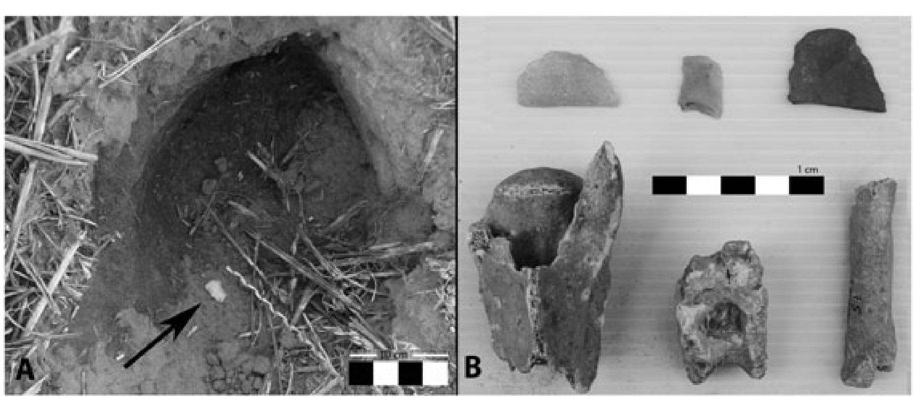

Figure 2. (A) A modern *C. villosus* burrow with archaeological lithic materials at its entrance in EG2. (B) Archaeological materials recovered from modern burrows: Sierras Bayas Group orthoquartzite lithic tools and flakes; Lama guanicoe cervical vertebrae, astragalus and first phalanx.

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Macrauchenia patachonica. The last two species did not show evidence of anthropic modifications. Eggshells of *Rheidae* were also abundant. These remains were associated with lithic artefacts. A humerus of *L. guanicoe* from these levels exhibiting helical fracturing has been dated at 9250 ± 40 RCYBP (SR-6381) (Bayón *et al.*, 2004; Flegenheimer *et al.*, 2010).

Unit 2 was truncated in some areas by a burial pit of late-Holocene age, named Unit 3. This unit was the result of human burial action. There, primary and secondary burials dated ca. 2500 years BP were recovered. In this unit, most of the faunal remains were broken and their dimensions were less than 2 cm.

Along the stratigraphic sequence, galleries up to 90 cm deep were registered. Some of them were still active, while others had collapsed or were filled with sediments. Galleries were described according to Fowler *et al.*'s (2004) proposal. The burrows were 0.19 m wide, and its morphology corresponded to a unique main gallery, which in a point turned to 90° (Figure 5(a)). Some of these galleries had claw marks on their walls. Because of these burrows' features and the direct observation of a *C. villosus* individual inside a burrow during fieldwork, the burrowing agent was identified as belonging to this species (Frontini & Deschamps, 2007).

Galleries were emptied prior to excavations, and the materials present in the removed sedimentary matrix were put away into separate bags.

Results

Actualistic study

The mounds formed at the entrances of the burrows examined in the actualistic study are composed of sediments of volumes between 4 and 64 m^3. Notably, the mouths of the burrows found in Paso Mayor have lower amounts of sediments than those found in EG2. This may be because these burrows are located in a loose sand dune, which may have led to the rapid scattering of the mounds. In 84.37% of the burrows, remains were recovered from sediments (Table 2 and Figure 2(a and b)). Preliminary findings coming from burrows 1 to 7 were published in a previous paper (Frontini, 2009).

Modern remains were collected in both localities, but they exhibit dissimilar characteristics. In Paso Mayor, most of the remains (98%, $n = 449$) are stones from river pebble deposits currently present in the area. In the burrows near EG2, modern materials consist of fragments of granite ($n = 80$), which is being used to improve the internal roads of the agricultural establishment; a single glass fragment of unknown origin; and a piece of metal whose origin is presumably related to farming activities.

Archaeological remains that included pottery and lithic materials were also recovered from mounds located in both localities. Technological materials represent 88.24% ($n = 60$) of the archaeological sample; faunal remains reliably assigned to this category are very scarce ($n = 12$). The technological assemblage is composed of lithic remains, a few pottery fragments ($n = 1$) and pigments ($n = 1$). Lithic artefacts ($n = 58$) are mainly flakes (80%; $n = 48$). Two unifacial retouched tools and eight chunks were also recovered. Raw materials mostly consisted of orthoquartzite from the Sierras Bayas Group, although there were also some subarkose and boulder flakes.

Archaeological faunal remains were not recovered at mounds from Paso Mayor. They were only collected in EG2. Bone fragments were identified as belonging to *L. guanicoe* (guanaco), *Ozotoceros bezoarticus* (Pampaean deer) and Rheidae (a South American Family of flightless bird). In connection with the first two species, mostly appendicular skeleton parts were found, whereas in the case of Rheidae, only fragments of eggshells were collected. These species are accounted for in the archaeofaunal assemblage of the site.

Regarding archaeological materials removed by armadillos, 83.78% ($n = 62$) were shorter than 2 cm. To a lesser extent, larger remains with a length up to 7 cm were also found. These larger specimens were all bone shaft fragments (Figure 3).

The state of the archaeological material faunal remains presented weathering stages 3 and 4 (Behrensmeyer, 1978). They were mainly fractured (75%, $n = 9$) (Figure 4). From the damaged items, 89% presented straight light-coloured fractures. They correspond to a first phalanx, a cervical vertebra, a distal humerus and a metapodial fragment, all corresponding to *L. guanicoe*, and four Rheidae eggshells. It is inferred that all of them are taphonomic modern fractures. Only two elements show fresh fractures whose origin is archaelogical. These are an *L. guanicoe* first phalanx and a mammalian shaft with helical fracture.

In contrast, in the lithic assemblage, fragmented materials are observed in the same proportion as the complete materials (Figure 4).

Case study: El Guanaco Site 1

A total of 446 remains, both modern and archaeological, were gathered from the galleries (Table 3). It was not possible to establish whether the material was

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Table 2. Materials recovered from the mounds in surveyed present-day burrows

Burrow N°	Remains	Quantity	Description	Origin
1	No materials			
2	No materials			
3	No materials			
4	No materials			
5	Lithic	5	Flakes	Archaeological
		2	Debris	Archaeological
		3	Granite used for road building	Modern
	Faunal remains	2	*Lama guanicoe* (1 astragalus; 1° phalanx with impact points)	Archaeological
		4	Dasypodidae indet. (plates)	Indet.
		9	Bone fragments indet.	Indet.
	Modern	1	Glass	Modern
6	Lithic	5	Flakes	Archaeological
		1	Debris	Archaeological
		3	Granite used for road building	Modern
	Faunal remains	2	*Lama guanicoe* (1 humerus with impact negatives; 1 cervical vertebrae)	Archaeological
		1	*Ozotoceros bezoarticus* (metapodial epiphysis)	Archaeological
		2	Dasypodidae indet. (plates)	Indet.
		29	Bone fragments indet.	Indet.
7	Lithic	10	Flakes	Archaeological
		2	Stone tools	Archaeological
		3	Debris	Archaeological
		70	Granites used in the roads building	Modern
		2	Calcrete fragments	Indet.
	Faunal remains	1	*Lama guanicoe* (lunar)	Archaeological
		5	Dasypodidae indet. (plates)	Indet.
		20	Bone fragments	Indet.
8	Lithic	5	Flakes	Archaeological
		4	Granite used for road building	Modern
	Pottery	1	Fragment	Archaeological
	Faunal remains	1	*Lama guanicoe* (metapodial fragment)	Archaeological
		3	Dasypodidae indet. (plates)	Indet.
		1	Shaft fragment from large mammal, with helicoidal fracture.	Archaeological
		8	Bone fragments indet.	Indet.
9	Lithic	2	Flakes	Archaeological
10	Lithic	1	Flake	Archaeological
11	Lithic	10	7 flakes, 1 pigment, 2 debris	Archaeological
	Faunal remains	13	13 bone fragments (2 thermally altered)	Indet.
		1	*Ctenomys* sp. (mandible fragment)	Indet.
		3	Dasypodidae indet, 3 plates (1 thermal altered)	Indet.
12	Lithic	2	Flakes of orthoquartzite from the Sierras Bayas Group (OGSB)	Archaeological
	Faunal remains	2	Bone fragments	Indet.
	Modern	1	Metal	Modern
13	No materials			
14	Lithic	1	Gravel flake	Archaeological
		2	Debris	Archaeological
15	Lithic	63	62 pebble; 1 calcrete fragment	Modern
	Faunal remains	2	*Plagiodontes* sp.	Modern
		2	Mollusca indet.	Modern
16	Lithic	21	1 calcrete fragment, 20 pebbles	Modern

(*Continues*)

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Table 2. (Continued)

Burrow N°	Remains	Quantity	Description	Origin
17	Lithic	18	Pebbles	Modern
	Faunal remain	1	Egg shell fragment	Modern
18	Lithic	1	Flake	Archaeological
18		12	Pebbles	Modern
19	Lithic	10	Pebbles	Modern
20	Lithic	2	Flakes	Archaeological
	Lithic	33	Pebbles	Modern
	Faunal remains	1	Mollusca indet.	Modern
21	Lithic	1	Pebble	Modern
22	Lithic	3	Flakes	Archaeological
	Lithic	35	Pebbles	Modern
23	Lithic	9	Pebbles	Modern
24	Lithic	4	Pebbles	Modern
25	Lithic	1	Flake	Archaeological
	lithic	17	Pebbles	Modern
26	lithic	29	Pebbles	Modern
	Faunal remains	3	1 *Austroborus lutescens*, 1 *Plagiodontes* sp.; 1 *bulla* from small animal	Modern
27	Lithic	22	Pebbles	Modern
28	Faunal remains	1	*Austroborus lutescens*	Modern
28	Lithic	12	Pebbles	Modern
29	Lithic	18	Pebbles	Modern
29		1	Flake	Archaeological
30	Lithic	53	Pebbles	Modern
30	Lithic	1	Flake	Archaeological
31	Lithic	77	Pebbles	Modern
32	Lithic	16	Pebbles	Modern
TOTAL		711		

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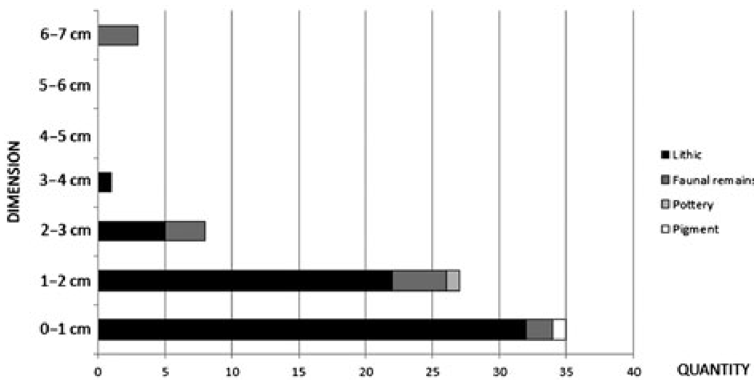

Figure 3. Size of the archaeological materials recovered from modern *C. villosus* burrows.

standing at the mouths of the burrows. The remains contained in the removed sediments were collected considering the gallery as a whole and not by grids, which prevented the mouths of the burrows from being located. On the other hand, it could be hypothetically assumed that the mouths of the burrows were outside the excavated sectors.

With regards to modern material, it corresponds to 17% of the total elements recovered. As reported by Frontini and Deschamps (2007), modern material corresponds to faunal remains belonging to taxa such as Anura, *Lepus europaeus* and *Zaedyus pichiy*. These taxa do not come from the original archaeological context, but were probably introduced when the *C. villosus* burrows were recolonized. *Lepus europaeus* is not a native species and was introduced in the 19th century. The remaining taxa inhabit the area and recolonize other animals' burrows. The material belonging to present species presented weathering stage 1.

The archaeological assemblage recovered from inside the *C. villosus* burrows is composed of lithic artefacts and faunal remains from species that are nowadays missing from the region. Lithic raw materials predominantly consist of orthoquartzite from the Sierras Bayas Group, coinciding with the lithic materials in the non-disrupted areas that were excavated (Bayón *et al.*, 2004). The faunal assemblage from the removal context is formed by 13 elements, five out of which belong to *L. guanicoe*, while the rest are fragments of Rheidae eggshells (Figure 5(b)).

Regarding material length, the size of the remains recovered from EG1 S1 is similar to that of the materials found in current burrows. In EG1, 80% was less than 2 cm long ($n = 358$). Only 13 items of the remains are larger than 5 cm, and only one of them is longer than 10 cm (Figure 6). The largest remains are exclusively bone fragments: a proximal epiphysis of a guanaco humerus, a fragment of a guanaco distal femur and two fragments from the shaft of a large mammal.

The state of lithic artefacts and faunal remains differs. Whereas only 35% ($n = 23$) of the lithic materials are fragmented, nearly all bone remains are fractured (95%, $n = 358$) (Figure 7). Different types of fragmented bones were recognised. First, seven elements presented fractures originated from fresh bone. Second, taphonomic damages were recognised in the rest of the assemblage, presenting straight edges as a result of dry breakage. This high proportion of fragmented

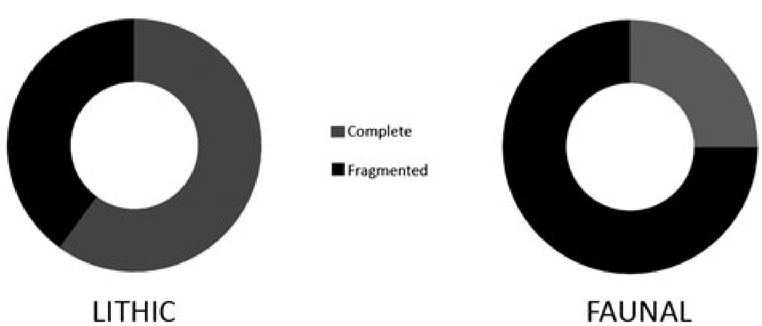

Figure 4. Preservation of the archaeological materials collected.

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Table 3. Materials recovered from the burrows at EG1 S1

Remains	Quantity	Description	Origin
Lithic	2	Cores (1 OGSB and 1 from chert)	Archaeological
	46	Flakes	Archaeological
	4	Artefacts	Archaeological
	1	Pigment	Archaeological
	7	Calcrete fragments	Indet.
	12	Debris	Archaeological
Faunal remains	319	Indet bone fragment	Indet.
	11	Rodentia indet	Indet.
	4	*Ctenomys* sp., (3 molariforms, 1 mandible fragment)	Indet.
	1	Microcavia (1 molar)	Indet.
	2	*Lagostomus maximus* (1 proximal femur; 1 fragmented molariform)	Indet.
	3	Anuro (long bones)	Modern
	1	Herbivorous molar	Indet.
	5	*Lama guanicoe* (astragalus, px scapula, px humerus; femur with helicoidal fracture; 1 incisor)	Archaeological
	1	Medium-sized bird: ds. tibiotarsal	Indet.
	8	Rheidae, shell egg fragments	Archaeological
	2	Dasypodidae (1 distal phalanx, 1 plate)	Indet.
	7	*Chaetophractus villosus* (molar, 3 thermoaltered plates, 3 fixed plates)	Indet.
	4	*Zaedyus pichiy* (plates)	Modern
	6	*Lepus europaeus (*2 mandible fragments; 2 molariforms, 1 calcaneus; 1 pelvis)	Modern
TOTAL	446		

Figure 5. (A) *Chaetophractus villosus* burrows in El Guanaco Site 1 Sector 1. (B) Archaeological materials recovered from these burrows: four orthoquartzites from the Sierras Bayas Group flakes, a *Lama guanicoe* proximal humerus and a mammalian shaft with helical fracture.

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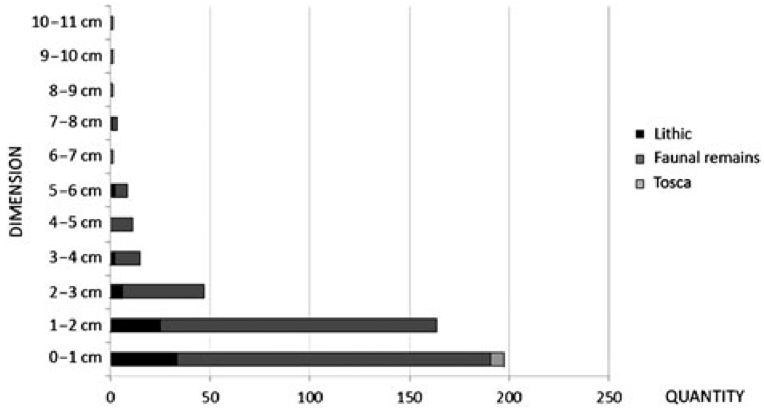

Figure 6. Size of materials collected inside the burrows in EG1 S1.

bones could be related not only to the *C. villosus* burrowing activity but also to the archaeological context of the site. Materials could have been broken previously by the human action of digging for burials.

Discussion and conclusions

The information gathered through the actualistic studies conducted in current *C. villosus* burrows allows us to make some inferences about the role of this species as a taphonomic agent in archaeological sites.

First of all, this taxon has inhabited the region since the Late Pleistocene and adapts to several weather and environmental conditions (Vizcaíno *et al.*, 1995). In the environments studied here—lake and fluvial—different sediments are present. While in the context of the lake (EG2), $CaCO_3$-rich sediments are predominant, in the fluvial environment (Paso Mayor), soils are sandy. In both environments, intense *C. villosus* burrowing was observed. This armadillo directs the mouth of the burrows against the direction of prevalent winds in each area (Abba *et al.*, 2005). This accounts for the orientation differences in each surveyed locality. Thus, in EG2, burrow mouths are mainly oriented north, while in Paso Mayor they face West.

Secondly, *C. villosus* usually modifies the spatial patterning of the materials. The findings presented in this paper show that at least some materials are accumulated on the ground surface, in the mounds that pile up next to the entrances of the burrows after they are dug by the armadillos. This characteristic would have a material correlate in archaeological deposits, forming discrete accumulations of materials. However, the archaeological visibility of this feature is not clear enough. At least at EG1 S1, it was not recognised.

This information can be added to the conclusions of Mello Araujo and Marcelino's (2003) experimental study. They observed that (1) the vertical movement of artefacts by armadillos is not preferential; (2) there is no significant correlation between artefact weight and displacement degree; (3) cultural horizons 20 cm apart from each other can be mixed by armadillos activities; and (4) the animal activity leaves distinctive traits

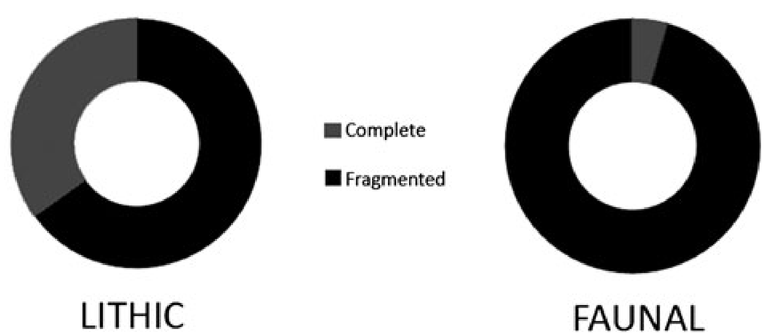

Figure 7. Preservation of the archaeological materials recovered in EG1 S1.

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(accumulation of materials along the animal trajectory) that can be identified during excavation (Mello Araujo & Marcelino, 2003).

In addition, regarding the type of materials, it can be stated that *C. villosus* removes archaeological materials from deposits and that also external modern elements are introduced on its burrows. From the actualistic analysis, we conclude that the proportion of modern material in current active burrow varies, depending on the context. While in burrows surveyed at EG2, modern materials correspond to 27% of the total, in Paso Mayor, the deposit consists mostly of modern materials (98%). The scarcity of archaeological remains in this area may be an indicator that the length of the site fails to reach the base of the dune, where prospecting was conducted.

From the burrows examined during excavation in EG1 S1, both archaeological and modern remains were collected, although the amount of archaeological materials recovered was higher. In those galleries, the only modern materials found were faunal remains of living species. This confirms the proposal of Frontini and Deschamps (2007) concerning the incorporation of remains that did not belong to the original deposits. The modern faunal materials show a low weathering stage different from that recognised in archaeological materials.

Finally, the materials collected in modern burrows are predominantly small (less than 2 cm), but there are larger remains (about 6 cm long). These larger remains are exclusively bones. The size of remains is one of the main variables considered in creating disturbance models for other species (Bocek, 1986; Johnson, 1989; Bocek, 1992). In the case of pocket gophers, different studies pointed out that these rodents move and pile up elements smaller than 6 cm on the ground, which matches the average width of their burrows, often generating stone lines. In addition, considering the size of the burrow and that of the animal, remains of up to 20 cm could possibly be vertically moved by *C. villosus*. However, this analysis shows that rather small materials accumulate on the ground's surface and that only exceptionally does the armadillo remove larger items (up to 7 cm long), which are exclusively bone fragments—a fact that has more to do with weight than with size.

The conservation degree is also similar in both cases under study. In the actualistic record as well as in the excavation of EG1 S1, the faunal remains recovered were mostly broken, whereas the percentage of fractured lithic artefacts was almost equal to that of complete ones. The effects of animals as agents on the modification of lithic materials have been analysed mainly within medium- and large-sized mammals, including humans (McBrearty *et al*., 1998; Weitzel, 2010). These last agents produce movement, burial, exposure, fracture and markings on lithic artefacts by trampling and kicking. According to an experiment carried out by Weitzel (2010) on orthoquartzites, human trampling on lithic tools on a loamy soil produces low breakage ratios (10% of the experimental tools). Therefore, breakage is linked to the physical properties of the materials, and the relation between width, length and thickness influences the chances of breakage. Items ranging from 2 to 3 mm in length and of proportional thickness are hardly fractured by human trampling (Weitzel, personal communication, 2011). Although experimentation is needed for flake fractures, it is possible to consider that the lithic broken materials were probably fractured in the original depositional context and that they were not fractured as a result of *C. villosus* activities.

With regards to bone fragmentation, bone material was probably broken by the burrowing action of *C. villosus*. The taphonomic modern fractures registered on actualistic bones allow to get to this conclusion. Nevertheless, it could be an equifinality problem because these fractures did not present features different from other agents. This theme needs deeper experimental investigation.

In conclusion, it could be stated that it is important to highlight several ways of studying the role of *C. villosus* as a taphonomic agent. Actualistic studies enrich our understanding of natural and cultural processes involved in the genesis of archaeological materials, mainly because of its usefulness to state, contrast and corroborate hypothesis. Nevertheless, the actualistic data presented in this paper need to be increased.

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