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When the barn-owl feasted on bats, an approach to taphonomic analysis

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Abstract

Small vertebrates are a key proxy for paleoenvironmental and paleoclimatic reconstruction, but a previous taphonomic analysis of the paleontological assemblage is needed before facing this kind of approach. Works concerning taphonomy of preyed small vertebrates are abundant in the literature, but chiropters are not usually included as they are only rarely predated. Here we analysed the content of two barn-owl (*Tyto alba*) pellets that exclusively contained bat remains. Our aim is to assess the effects of digestion inflicted by this predator on certain bat skeletal elements, specifically mandibles and lower teeth. All bat remains were assigned to *Pipistrellus* sp. They mostly presented slight alteration of the mandible and non-altered enamel, which is an expected result based on previous literature concerning this type of predator. Nevertheless, a few specific specimens showed much more intense alteration. This is most probably due to predator-related factors, although a higher degree of age-related tooth-wear in a specific bat cannot be dismissed.

Keywords: taphonomy, Chiroptera, *Tyto alba,* pellet, digestion.

1. Introduction

The identification of the accumulation origin of a paleontological assemblage is a key issue that needs to be addressed before carrying out paleoenvironmental or paleoecological studies, and taphonomy is the main scientific discipline in understanding the processes involved. Being small-mammals a valuable proxy in Quaternary paleoenvironmental approaches, there are several works concerning taphonomic modifications related to small-mammals predation (Andrews, 1990; Fernández-Jalvo *et al.,* 2016, and references therein). However, the authors usually do not include bats: chiropters are rarely preyed upon by raptors, and so their remains are usually in a small proportion or absent within bone assemblages at predators' occupational levels (Kowalski, 1995).

The main objective of this work is to assess the alterations observed on certain bat remains (mandibles and lower teeth) found within two pellets of the barn-owl *Tyto alba*, collected during a field season, in 2011. The barn-owl is an opportunistic predator which is considered to produce light to moderate levels of digestion (Andrews, 1990; Fernández-Jalvo *et al.*, 2016). The bat remains were expected to appear non-affected or only slightly modified, according to the results reported for mandibles of shrews (Eulipotyphla, Mammalia) for light to moderate levels of digestion (Fernández-Jalvo *et al.,* 2016). Among small mammals, soricines present the most similar teeth to microbats: they both are dilambdodont (with high cusps and no dentine exposed in the occlusal surface) and mainly adapted to insectivorous diet; even if some shrews have red, iron-containing teeth (which never happens in bats), most works on small mammals taphonomy do not distinguish between digestion extent in red-toothed shrews and white-toothed shrews (see Andrews, 1990; Fernández-Jalvo *et al.*, 2016).

2. Material and methodology

Several recent barn-owl (*Tyto alba*) pellets were recovered in 2011 near Escatrón, south-east Zaragoza (Spain) by J. I. Canudo and G. Cuenca-Bescós. Two of them (Eg01 and Eg02) contained exclusively bat remains, and they have been analysed here.

The owl pellets were used for laboratory practices with the fourth-year students of the Geology degree

of the University of Zaragoza, back in 2011, and the bones were recovered by washing and sieving the pellets separately. The remains have been analysed using a stereomicroscope Olympus SZ61, and photographed with an attached LC20 camera. Bats have been identified following Felten *et al.* (1973), Dupuis (1986) and Dodelin (2002). Surface alterations have been analysed on mandibles and lower teeth, after Fernández-Jalvo *et al.* (2016). We have identified different degrees of surface alteration (that have been codified based on their intensity) affecting three elements: mandible bones, alveoli and teeth enamel (following Fernández-Jalvo *et al.,* 2016). We used an intact mandible of the same bat genus from an individual deceased by natural death as a non-altered reference (see codification of alteration degrees in Tab. 1). As the recovering of the remains did not follow a systematic methodology, nor was ideally careful in its performance (lab practices by unexperienced students), we have not considered here the breakage degree nor the teeth detachment.

	non-affected (0)	light (1)	moderate (2)	heavy (3)
Digestion on mandible bone	none	polished shine	corroded	lost of original shape
Digestion on alveoli	none	polished alveoli edges	rounded and pitted alveoli edges	lost of original shape
Digestion on teeth enamel	none	mate areas	exposed dentine	collapsed dentine

Tab. 1. -Codification of the alteration degrees observed on three mandible parts: bone, alveoli and teeth enamel (based on Fernández-Jalvo *et al*., 2016)

3. Results

All the recovered remains have been assigned to *Pipistrellus* sp. (Fig. 1). Each pellet contains at least 8 individuals (MNI_{eg01}=8, MNI_{eg02}=8). 16 mandibles were recovered from Eg01, and 14 from Eg02. The cause of the absence of two right mandibles in Eg02 is unclear, but a mistake in the recollection process during lab practices cannot be dismissed. The mandibles show different degrees of alteration on each of the three considered parts (mandible bone, alveoli, teeth enamel), where all mandible bones were affected by digestion (most of them lightly, some moderately). On the other hand, teeth enamel appears mostly unaltered, with the exception of one specimen, coinciding with moderate alterations in mandible bone and alveoli. Teeth with heavy digestion (collapsed dentine) have not been found, either attached to mandibles or isolated. Based on the different alteration patterns observed, the mandibles from the two pellets have been classified within four groups (Categories I to IV, Tab. 2).

Most of the mandibles are related to Category II, characterized by lightly digested mandible bone, light to moderately digested alveoli and non-affected teeth enamel. The proportion of mandibles presenting different alteration patterns differs in each pellet (Tab. 2). All the mandibles show, at least, partial detachment of teeth, while several have no attached teeth and thus some of them could not be certainly assigned to categories II or III.

	Alteration description			Abundance	
	mandible bone	alveoli	teeth enamel	Eg01	Eg02
Category I	light (1)	non-affected (0)	non-affected (0)	30%	0%
Category II	light (1)	light to moderate (1, 2)	non-affected (0)	65%	75%
Category III	light (1)	moderate (2)	moderate (2)	5%	0%
Category IV	moderate (2)	heavy (3)	unknown (no teeth)	0%	25%

Tab. 2. -Alteration patterns categorizations, and mandible distribution per category and pellet.

4. Discussion and conclusions

The analysed pellets lacked any remain of other small-mammals (nor rodents or soricines), so our results cannot be directly compared to the digestion categories in Fernández-Jalvo *et al*. (2016). However, mandibles related to Category II (the most abundant in both pellets) present similar characteristics to those of soricines within pellets with moderately digested rodent teeth (Fernández-Jalvo *et al.,* 2016), i.e. polished bone but mostly non-affected enamel. This is congruent with our original expectations, as *Tyto alba* is considered a Category 1 predator (Andrews, 1990) which usually produces absent or minimal digestion signs.

It is striking, though, that a few of the bat remains show quite high levels of alteration: one individual with alteration Category III has been identified in Eg01, and two individuals with alteration Category

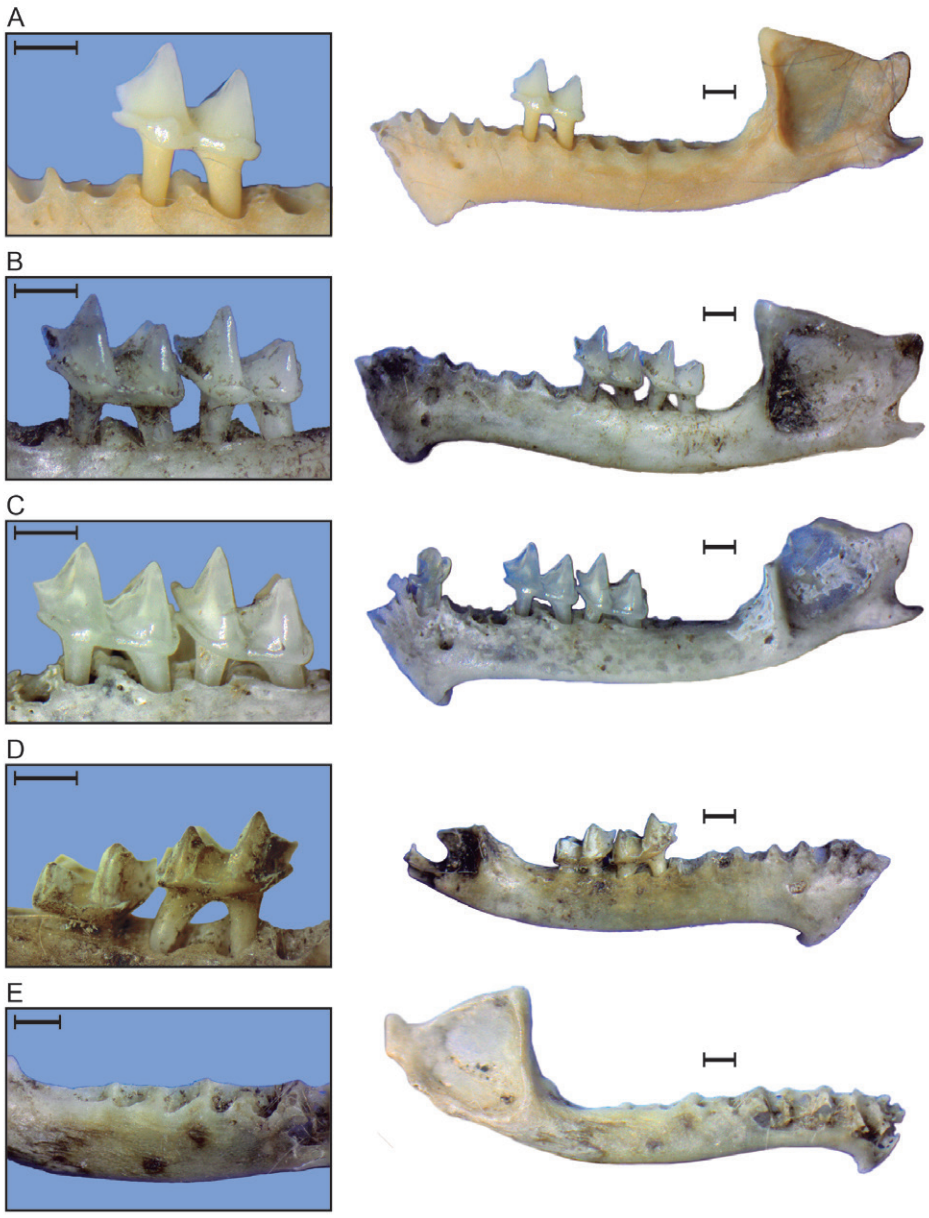

Fig. 1. -*Pipistrellus* sp. mandibles with different degrees of surface alteration related to predation effects, detailed view at right and overview at left. A-Non-affected mandible from a non-predated individual; B-mandible with alteration Category I; C-mandible with alteration Category II; D-mandible with alteration Category III; E-mandible with alteration Category IV. Scale=0.5 mm.

IV in Eg02 (Fig. 1). In the first case (the only one where teeth-enamel dissolution has been observed), the higher enamel corrosion could be favoured by a more accused, age-related tooth-wear in this particular individual (Fig. 1): in *Pipistrellus*, wear-facets mainly develop on the lateral surfaces of the talonid and the trigonid (see a detailed study in Hielscher *et al.,* 2015). On the other hand, several possible explanations for these high-level alteration degrees observed on a few specimens could yield on the biology of the barn-owl. The digestion of the preys can take up to 10 hours; when finished, the pellet is regurgitated. If the bird eat more than one prey before the process is complete, all the remains are consolidated into one pellet, and the first prey overtake two digestion processes (Gill, 2007). Also, the digestion pH in birds can change depending on hunger level, birds age and seasonality (Gill, 2007). Bats are not a common prey for the barn-owl (Bruce *et al.*, 2020). As no other small vertebrate group has been found inside the analysed pellets, both could have been produced by a single, starving barn-owl specialized in bat feeding in famine situations, which could explain the presence of a few remains with high alteration degree in teeth and mandibles.

As final conclusions, there are two remarkable points. Firstly, most of the *Pipistrellus* mandibles presented polished bones, slight to moderately

dissolved alveoli and non-affected teeth enamel (classified as alteration Category II), resembling the characteristics observed on soricines within pellets with moderately digested rodent teeth published in previous literature. Secondly, the alteration degree of the analysed mandibles varies even within the same pellet: three specimens showed stronger digestion, most probably due to predator-related factors, although a higher degree of age-related tooth-wear in a specific specimen (the only one with moderately digested teeth) cannot be dismiss.

The small sample studied here does not allow us to jump into further conclusions. A deeper analysis will shed light on this, both by including other skeletal remains and by studying other pellets from the same site containing not-chiropteran remains.

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