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Osteophagia and dental wear in herbivores: actualistic data and archaeological evidence

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ABSTRACT

The ability of herbivores to produce damage in bones and antlers has recently been described by the present authors (Cáceres et al., 2011), showing several cases of modified bones and various stages of bone modification due to osteophagic behavior by herbivores. Herbivores chew and eat bones and antlers to make up for mineral scarcity in their diet. In this paper we describe how the consumption of bone and antlers by herbivore can result in distinct differential tooth wear, breakage and the loss of some dental pieces. This damage has also been identified in fossils. These preliminary results are especially relevant in archaeological contexts, because this marked tooth wear can be mistaken for dental disease or lead to the incorrect assignment of age to the animals.

1. Introduction

The consumption of bone and antler by herbivores is associated with a diet deficient in minerals (calcium and phosphorus, primarily), which are supplied by the ingestion of organic materials (Theiler et al., 1924; Gordon et al., 1954; Barrette, 1985; Denton et al., 1986; Warrick and Kraussman, 1986; Johns and Duquette, 1991; Grasman and Hellgren, 1993; Richard and Juliá, 2001; Mitchell et al., 2005; Bredin, 2006; Bredin et al., 2008). Recently, we published a paper on the ability of herbivores to eat bones and antlers and on the bone modifications that this behavior causes (Cáceres et al., 2011). This study, which was undertaken in the natural reserve of Bosque de Riofrío (Segovia, Spain), based on a total number of 249 chewed bones by red deer (*Cervus elaphus*) and fallow deer (*Dama dama*), has allowed us to obtain a deeper understanding of different forms of bone damage associated with the osteophagic activities of herbivores.

Osteophagia is defined as abnormal craving for nonfood items. Sutcliffe (1973) refers that, apart from domestic animals (cow and sheep), osteophagia has been observed in red deer, reindeer, camels, giraffes, wildebeest, kudu, gemsbok and sable antelopes. More exceptional is the case referred by Wald (2011) of osteophagia by a grizzly bear (*Ursus arctos horribilis*) chewing a shed moose (*Alces alces*) antler. Sutcliffe (1973, 1977) summarized descriptions by several observers and previous authors that witnessed this phenomenon among domestic and wild artiodactyls. According to these observers, the herbivores introduce bones into their mouth lengthways and sideways, like a cigar, and with the zigzag movements of their jaws produce the fork shape (Sutcliffe, 1977).

Traditionally, the osteophagia in herbivores has been identified by the presence of bones and antlers with fork morphology (Fig. 1). This morphology is a fairly advanced stage of damage. However, in the early stages herbivores can also produce grooves, rounded and polished ends, rough surfaces and the irregular disappearance of the epiphyses (Sutcliffe, 1973, 1977; Brothwell, 1976; Johnson, 1985; Justus and Turner, 1990; Kierdorf, 1993, 1994; Cáceres et al., 2007, 2011). These modifications may be similar to those produced by

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Fig. 1. Bones chewed by herbivores from the Bosque de Riofrío (Segovia, Spain), showing the characteristic fork morphology. From top left to bottom right: Tibia, radius, metatarsal, metacarpal, mandible, proximal femur, pelvis, antler, vertebra and rib. These anatomical elements, complete or broken, have a specific format and size/weight suitable for deer to chew (Cáceres et al., 2011).

carnivores, although there are diagnostic criteria for differentiating them (Cáceres et al., 2011). The main difference resides in the state of the bone (fresh or dry) when consumption begins. Carnivores have a nourishing purpose and thus consume fresh bones, whereas herbivores do not have a nutritional intention and therefore consume dry bones. As a result, cracked and weathered surfaces are associated with the grooves produced by herbivores (Cáceres et al., 2011).

When monitoring carcasses in the Bosque de Riofrío (Segovia, Spain), we observed that some jaws had a heavy and distinct differential wear. This dental wear did not correspond with the individual ages assigned to the animals by rangers on the basis of antler development. In addition, we observed tumors and other pathologies in jaws, as well as unusual breaks in the teeth and a loss of teeth in some of the specimens that we studied (Fig. 2). Differential wear and pathologies affected more intensively the middle positions of the tooth row. The way herbivores hold and chew bones '*like a cigar*' led us to consider the relationship between this unusual differential cheek tooth wear (incisors are free of wear) and the practice of osteophagia so widespread in Riofrío.

Consequently, a review has been undertaken on the maxillae and mandibles collected in Riofrío in order to characterize the damage on the teeth associated with the practice of osteophagia. The present study also aims to find criteria for identifying osteophagic practices in the paleontological and archaeological record on the basis of differential dental wear. Therefore, we have