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Review

Identifying sheep (*Ovis aries*) fetal remains in archaeological contexts

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ABSTRACT

Studies on the identification of fetal sheep remains in archaeological sites are scarce in comparison to the abundant literature addressing methods for postnatal age determination. However, perinatal studies can provide important information about sheep flock management in the Neolithic period.

Motivated by the extensive fetal and neonatal assemblages recovered in the Neolithic and Bronze Age levels of El Mirador cave (Sierra de Atapuerca, Spain), we have identified and distinguished the remains using morphological criteria complemented by osteometric criteria.

Skeletal development during the fetal period is less affected by the agents that can influence postnatal skeletal development (genetic, environmental, etc.). *A priori*, this makes age determination using actualistic data in fetal remains more reliable than in postnatal remains. Starting from these premises, the perinatal remains from El Mirador cave were analyzed using the osteological collection of fetal and neonatal individuals of the Rasa Aragonesa breed from the IPE (Instituto Pirenaico de Ecología, Jaca, Spain). Veterinary studies based on bone center ontogenesis and fetal age identification methods using metric criteria were also employed.

The identification of age and the distinction of fetal and neonatal remains in the El Mirador cave assemblages based on qualitative anatomical criteria were consistent with the results obtained from osteometric data, specifically from the diaphyseal length measurement. In addition, the large number of specimen in the El Mirador assemblages made it possible to distinguish different fetal phases in accordance with skeletal developmental phenomena.

Contents

1. Introduction

References to the presence of animal fetal remains in archaeological sites are usually limited and essentially restricted to domestic species assemblages in Holocene sites (e.g. Boessneck and

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von den Driesch, 1979; Clason, 1982; Geddes, 1983; Zeiler, 1986; Benson and Cook, 2001; Howell-Meurs, 2001; Gómez, 2003; Alhaique, 2008; Nieto et al., 2008; Grimm, 2009). This scarcity may be attributed to different causes brought about by either human decisions (cultural, economic, ritual, etc.) or taphonomic processes. In reference to the latter, some authors have described the age-correlated differential destruction of bone. Ethnoarchaeological and experimental studies show that adult individual remains present higher survival rates than immature animals due to the action of the different taphonomic processes at work in archaeological assemblages (Payne, 1973; Binford and Bertran, 1977; Lyman, 1994; Munson, 2000).

In farming community sites, fetal and neonatal remains usually come from domestic species and essentially appear in livestock breeding sites or in ritual contexts (Geddes, 1983; Gómez, 2003; Helmer and Vigne, 2004; Helmer et al., 2005; Miracle and Forenbaher, 2005; De Grossi and Solinas, 2006; Nieto et al., 2008; Martín et al., 2015). Fetal identification makes it possible to distinguish a very important period in flock management and survival: the breeding period. Furthermore, fetal or perinatal bones can reveal failures in gestation or birthing, slaughter, or the natural birthing of pregnant females whose presence in sites could be difficult to determine using other identification criteria (Prummel, 1988).

A specific methodology for identifying these fetal remains in archaeological sites has not been extensively developed, probably due to the above-mentioned factors. In contrast, age determination studies on post-birth individuals are extremely common in archaeological faunal assemblages. They are mainly based on tooth wear and eruption (e.g. Payne, 1973; Grant, 1982; Deniz and Payne, 1982; Rolett and Chiu, 1994; Hillson, 2005; Greenfield and Arnold, 2008) and bone fusion criteria (e.g. Barone, 1969; Silver, 1969; Moran and O'Connor, 1994; Zeder, 2006; Popkin et al., 2012). In Holocene assemblages, many studies have focused on the economic management of domestic animals by means of the reconstruction of culling age profiles and the determination of the seasonality of human occupations (Helmer et al., 2005; Miracle and Forenbaher, 2005; Marom and Bar-Oz, 2009; Bréhard et al., 2010; Wright et al., 2014).

Nevertheless, from a methodological point of view, the development of skeletal elements during the fetal period exhibits a higher degree of uniformity than in more mature individuals (Wenham, 1981), making fetal identification at archaeological sites more accurate than age identification in other specimens.

The most notable work on fetal remain identification is that published by Prummel, (1987a, 1987b, 1988). This author presented different anatomical diagnostic criteria to distinguish fetal bones from four domestic species: cattle, pigs, horses and sheep. Prummel (1987a; 1987b) presented the anatomical features of each animal's skeletal elements to identify fetal remains and to differentiate between the different species, but this does not make it possible to determine fetal age from day of conception. For this purpose, Prummel (1988) compiled a summary of veterinarian studies that gave equations for the estimation of fetal age in days based on diaphyseal length. In the case of sheep, Prummel cites the works of Habermehl (1975), Rajtovà (1972a; 1972b), Richardson et al. (1976) and McDonald et al. (1977), all of whom used different bone measurements to estimate fetal age.

Beyond Prummel's works, information on fetal domestic animal development must be sought in zootechnical studies. In the specific case of sheep, these works focus on the estimation of fetal age for the purpose of improving ewe gestational monitoring in modern flocks (e.g. García-González, 1981a; Černy and Brandstatter, 1990; Santucci et al., 1993; Abreu et al., 2007; Léga et al., 2007; Dupré, 2009; Rihab et al., 2012; Waziri et al., 2012). The methodology employed is based on different fetometric techniques using sonography and X-ray (in live animals) (Abreu et al., 2007; Léga et al., 2007; Banan, 2012; Rihab et al., 2012) or direct measurements (in dissected animals) (Santucci et al., 1993). Some authors have applied the same techniques to study the anatomical development of different skeletal elements and organs (Harris, 1957; Černy and Brandstatter, 1990; Sivachelvan et al., 1996).

The combination of these fetometric and anatomical studies can be useful in fetal identification and age determination from conception in archaeological faunal assemblages.

Considering all of these premises and previous works, this paper focuses on the methodological application of these criteria to identify sheep fetal remains in archaeological sites and to determine their approximate age in days of gestation. First, sheep skeletal development data and their determining factors were considered with the aim of evaluating which criteria were applicable to perinatal archaeological assemblages. Second, these morphological criteria and metric equations were selected for the purpose of:

- Determining different morphological features on each skeletal element that allow fetuses to be distinguished from neonates.
- Determining the most reliable skeletal elements and their features to establish different fetal development stages or an approximate fetal age from conception.

Lastly, these criteria were applied to the Neolithic and Bronze Age ovicaprine perinatal assemblages from El Mirador cave (Vergès et al., 2002, 2008). These assemblages are quite large (Martín et al., 2015) and have allowed us to evaluate which diagnostic criteria are the most reliable for application in archaeological faunal contexts, in which bias and the fragmentation of remains are commonplace and make identification difficult.

2. Sheep skeletal development in the fetal period: process and determining factors

During gestation and postnatal development, two phenomena affect individual animals (Hammond, 1932, 1940):

i) Growth – increases in weight and size undergone by animals from conception to adulthood; ii) Development – changes in body structure, organ proportions and functions until the animals reach maturity.

The second phenomenon includes the animal's skeletal development. Skeletal development begins in the earliest phases of gestation, not long after the beginning of nervous system formation and before the beginning of the formation of the muscular system and body fat. In other words, the vital organs and skeleton are the first to develop, whereas organs related to production (fat, muscles, genitals) are the last to develop (Hammond, 1932, 1940).

The formation of most of the skeletal bones occurs from a cartilaginous precursor within which different ossification centers develop (Fletcher and Weber, 2013). A bone can be formed by one (primary) or by several (primary and secondary) ossification centers. The primary ossification centers in the long bones are the diaphyses, whereas secondary ossification centers are the epiphyses. Some elements, like basipodia, present only one ossification center.

Sheep gestation lasts from between 145 and 153 days, depending on the breed and the age of the ewe (Cambero, 1997). From the initial phases of skeletal development (around 41–45 days from conception), some primary ossification centers can be differentiated (Wenham, 1981). Secondary ossification centers appear in a more advanced gestation phase (Rajtová, 1972a, 1972b;