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A new method for ageing wild boar using dental measures

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ABSTRACT

Over the last decades, wild boar (*Sus scrofa*) populations in Europe have increased with impacts on agriculture, livestock and biodiversity. Thus, changes in population management for wild boar are increasingly important. Knowledge of the age structure of the population is crucial to designing effective management plans. However, the costs and efforts required to estimate the age of wild boar, primarily in the oldest animals, is problematic for managers and researchers. Here, we describe a new method to estimate wild boar age based on simple dental measures (the external aperture of the pulp cavity, root length and crown length from primary and secondary incisors). Our study was based on data from 93 wild boar of known age belonging to two different populations in central and south-eastern Spain. We propose a model based on Boosted Regression Trees (BRT). Our results show a final age estimation model that included all the explanatory variables proposed (dental measures) and showed a high percentage of estimated deviance (61%), obtained by cross-validation. Thus, at least in Iberian wild boar populations, our method constitutes a low-cost and reliable method for wild boar age estimation.

1. Introduction

Approaches and policies for wild boar (*Sus scrofa*) population management are changing throughout Europe. This is largely due to the rise in populations across the range of distribution as well as increasing density (Apollonio et al., 2010; Massei et al., 2015). This increase has led to problems in some regions, since wild boar can cause important crop damage and can facilitate the spread of some pathological conditions (García-Jiménez et al., 2013; Herrero et al., 2006; Onida et al., 2014; Schley et al., 2008).

Many studies have aimed to develop methods and approaches to designing and integrating management plans in wild boar populations (Fernández-Llario and Mateos-Quesada, 2003; Herrero et al., 2008; Keuling et al., 2008b). Knowledge of the age structure can be crucial to the study of many different aspects of these populations (seasonal and annual space use, incidence of different pathogens) and to developing hunting strategies as a measure to control populations (Bieber and Ruf, 2005; Keuling et al., 2008a; Risco et al., 2013). Thus, developing simple and accurate age estimation methods remains a central challenge.

Age estimation methods in suids are usually based on the study of tooth development. Traditionally, age has been estimated using patterns of tooth eruption and replacement but this method is only accurate in animals younger than 26–30 months of age (Anezaki, 2009; Choquenot and Saunders, 1993; Matschke, 1967; Oroian et al., 2010). Other methods have been developed to improve age estimations. These techniques, such as root apex closure (Habermehl, 1985), pulp cavity ratio (Sáez-Royuela et al., 1989), counting the incremental lines of tooth cementum (Clarke et al., 1992; Choquenot and Saunders, 1993; Quere and Pascal, 1984; Sáez-Royuela et al., 1989) or tooth wear (Choquenot and Saunders, 1993; Magnell, 2006; Oroian et al., 2010), seem to work properly in older wild boar. However, most of these methods are expensive or require laboratory procedures, which are often not available to managers or researchers.

In the present study, we recorded different measures from primary and secondary incisors of wild boar of known age with the aim to develop a simple and economical age estimation method for this species.

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2. Materials and methods

2.1. Study site

The study was carried out on two different estates. One estate is 700 ha and located in south-eastern Spain. The climate is Mediterranean, with annual precipitation around 810 mm/year and average temperatures of 6 °C in the winter months and 23 °C in the summer months. The habitat is Mediterranean forest, where the dominant tree species is the Holm oak (*Quercus Ilex*), interspersed with well-developed thickets with species such as *Cistus ladanifer, Erica spp* and *Genista anglica*. Wild boar density in this area was about 93 wild boars/km^2.

The other estate is located in central Spain spanning an area of 2000 ha. The climate is Mediterranean with continental influences, with annual precipitation around 550 mm/year and average temperatures of 3 °C in the winter months and 20 °C in the summer months. The dominant tree species are *Pinus sylvestris*, *Quercus pyrenaica* and *Quercus faginea*, interspersed with species such as *Cistus spp* and *Erica spp.* Wild boar density in this area was about 40 wild boar/km^2. We included two areas in this study to control for the possibility of different growth rates in different population, which could affect our methodology.

The game estates are completely fenced and supplementary food (cereal crops and special wild boar fodder) is regularly provided to wild boar. Both estates are divided into two different areas: a free ranging area, where wild boar live in natural conditions and where different game activities are carried out, mainly in the autumn–winter; and a 25 Ha breeding area (farm) where wild boar are bred in captivity and later released into the free ranging areas for hunting. All of the animals that are born in the farm areas are identified with a subcutaneous microchip (Friendchip, AVID Identification Systems, Spain) at the age of two or three months. These microchips are injected at the base of the left ear. Subsequently, at the age of 6 months, identified animals are released into the free-ranging areas where they live until they are hunted.

2.2. Animals

During the years 2012, 2013 and 2014, a total of 93 marked wild boar males were hunted in the two study areas (38 from the south-eastern estate and 55 from the central estate). The identification numbers of these animals were checked using a microchip reader and their ages were determined on the basis of the farms' data, ranging between 2 and 8.5 years old. The jaws from these 93 animals were collected and transported to the laboratory.

2.3. Dental measures

Some dental measures were used as possible estimators of wild boar age. Two lower incisors, the primary incisor (I1) and the secondary incisor (I2), were removed from each wild boar jaw. For each incisor we measured different parameters: external aperture of pulp cavity (the maximum diameter of the root aperture), minimum root length and maximum crown length (taken the most cervical position of the enamel-cementum junction at the labial crown surface as the landmark for measuring both maximum crown length and minimum root length) (Fig. 1). All the measures were taken with a digital calliper (±0.1 mm).

2.4. Development of the age estimation model

In order to explore the relationship between the dental parameters measured and age, the correlations between possible estimators and the actual age of the wild boars were studied. Some of the variables showed a good correlation with age but also showed correlations among the variables themselves, resulting in problems of multicollinearity (Fig. 2).

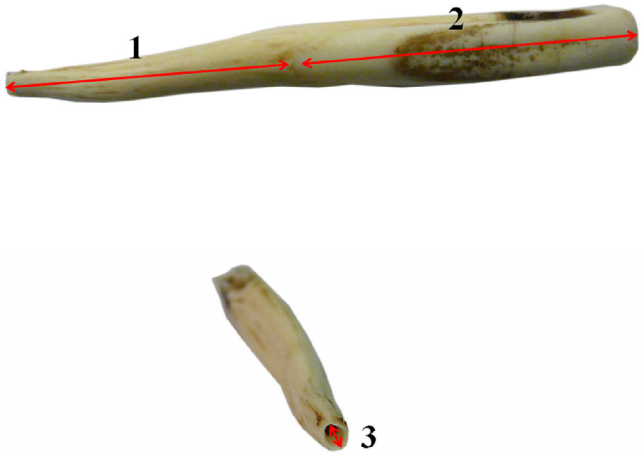

Fig. 1. Incisor measures; 1 minimum root length, 2 maximum crown length and 3 pulp cavity.

Collinearity refers to the non-independence of predictor variables and can be problematic for parameter estimations as it inflates the variance of regression parameters and, hence, potentially leads to the misidentification of relevant predictors in a statistical model (Dormann et al., 2013). One way to better assess multicollinearity than the assessment of the correlation matrix is to compute the variance inflation factor (VIF). The VIF quantifies the amount of multicollinearity in simple linear regression models. VIF is the ratio of the variance of each parameter in the linear regression model, when fitting the full model, divided by the variance of individual parameters if fit on its own (James et al., 2013). The smallest possible value for VIF is 1, which indicates the complete absence of collinearity. Often in the literature, a VIF value exceeding 5 to 10 is taken to indicate a problematic degree of collinearity. Table 1

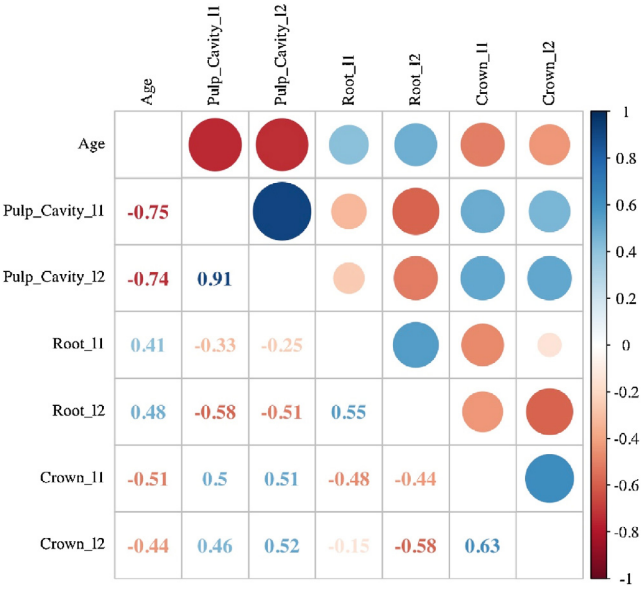

Fig. 2. Correlation analysis among different parameters measured in this study. Results show multicollinearity among dental measurements and a strong correlation between age and pulp cavity I1 and I2. The areas of the circles represent the absolute value of the correlation coefficient, while the colour represents the sign of the correlation. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)