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Original Investigation

Factors influencing red deer occurrence at the southern edge of their range: A Mediterranean ecosystem



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ABSTRACT

The red deer is in the Iberian Peninsula at the southwestern edge of its European range and although widespread, red deer ecology in Portugal remains poorly understood. By using pellet group counts, we investigate how habitat structure, vegetation composition and human disturbance affect red deer occurrence. Red deer distribution was positively associated with areas with high density of heather, Leguminosae plants and patches with high cover of shrubs, ground cover and tree cover. Red deer occupied areas further away from roads and from villages. Red deer distribution was negatively associated with agricultural fields and areas with high canopy cover.

In the perspective of the current climatic changes, continue research on red deer in these so-called edge populations represents an opportunity to assess the ecological responses within an evolutionary perspective and to provide important conservation suggestions for other countries located on the edge of its distribution range. The present results have implications for the conservation of red deer, emphasizing the need for wide range ecological studies. Red deer variation seems to be related to local factors rather than proximity to the edge of its range.

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Introduction

Global changes, mainly driven by human activities, are dramatically changing the geographic distributions of species (Parmesan and Yohe 2003). These changes are expected to have a stronger effect on marginal populations. Particular insights can be obtained by looking at the edges of a species range, especially from species with wide distributions.

In the Iberian Peninsula, several Palearctic species reach the southern edge of their distribution. One of these species is the red deer (*Cervus elaphus*). Red deer are widely distributed across Europe, occurring throughout most of the continent except in northern Scandinavia, Finland and Iceland (Zachos and Hartl 2011). In recent years, red deer have increased in both abundance and geographical range (Apollonio et al. 2010). Due to its wide distribution, this species has generated a large amount of research in different topics (Clutton-Brock et al. 2004; Apollonio et al. 2010; Zachos and Hartl 2011). As a result, today red deer is considered one of the best-known ungulates. Despite this, most studies focus on well-established populations of central Europe and Great Britain (e.g. Myrsterud et al. 2002; Clutton-Brock et al. 2004; Schaefer et al. 2008; Apollonio et al. 2010) and only a

few have focused on populations inhabiting the Mediterranean ecosystem (Papageorgiou 1978; Carranza et al. 1991; Lovari et al. 2007). Additionally, research in the Mediterranean area has challenged the traditional view of red deer and has highlighted important differences between northern populations and Mediterranean populations e.g. the Mesola red deer (NE Italy) shows modest body size, simplified antlers and a low reproductive performance when compared with northern populations (Mattioli et al. 2001) and the Sardo-corsican subspecies *Cervus elaphus corsicanus* (SW Sardinia, Italy) shows annual mean home range sizes much smaller than elsewhere (Lovari et al. 2007), a pattern also found in another Mediterranean area (Monfragüe, Spain) (Carranza et al. 1991).

The red deer is the largest native cervid in Portugal (Vingada et al. 2010). By the end of the 19th century the species faced the extinction however, in the three last decades, through reintroduction programs and natural dispersion, this population has recovered and is now common throughout much of the country (Vingada et al. 2010). In spite of this, there is a lack of information about which factors shape red deer distribution in Portugal. The Iberian red deer (*Cervus elaphus hispanicus*) is a subspecies of red deer inhabiting only areas of Spain and Portugal (Zachos and Hartl 2011). Hence, the preservation of this subspecies is of great interest to the wildlife conservationists, and basic knowledge concerning local populations is urgently needed to facilitate management decisions.

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Even though data on habitat selection of red deer on northernmost ecosystems are sparse, particularly in Norway (red deer northernmost edge), studies have suggested that red deer in Norway show a strong seasonal selection for forest habitat with more cover during summer while selecting pastures in spring and autumn (Mysterud et al. 2002; Godvik et al. 2009). Similar selection for covered habitats in summer has also been found in Rocky Mountain elk (Boyce et al. 2003). Various studies have shown that red deer responds to various types of human-induced disturbance (e.g. hunting, outdoor life, roads) (Phillips and Alldredge 2000; Jayakody et al. 2011; Sibbald et al. 2011). Contrastingly, previous studies on the Mediterranean ecosystem, characterized by very warm and dry summers and by mildly cool, wet winters, have showed that red deer selects areas with natural forests and/or Mediterranean maquis, far from roads and close to water sources (Puddu et al. 2009; Torres et al. 2012a).

In the light of the scarcity of data regarding red deer habitat use in Portugal, the southernmost country on the edge of its range, the main aims of this study were: (i) to analyse red deer occurrence in a Mediterranean landscape in the presence of a large range of factors; and (ii) to identify habitat variables that are relevant, at

different spatial scales, to red deer distribution. Our predictions, derived from other studies (e.g. Patthey 2003; Puddu et al. 2009), were that red deer would make more use of areas with large vegetation heterogeneity (i.e. areas with greater forage availability), and would make less use of areas near roads and human settlements since red deer populations experience a harvest pressure in Portugal and it is likely that hunting can induce responses similar to non-human predation risk (Frid and Dill 2002). Furthermore, human disturbance factors can influence red deer distribution as they may be considered as analogous to predation risk.

Material and methods

Study area

The study was carried out in the north part of Montesinho Natural Park and Serra da Nogueira, Trás-os-Montes, northeast Portugal, in an area of 75,000 ha (Fig. 1). The terrain consists of rolling hills with elevation ranges from 438 to 1481 m. The climate is mainly Mediterranean, although it has continental and Atlantic influences. Mean annual temperature varies between 3 °C

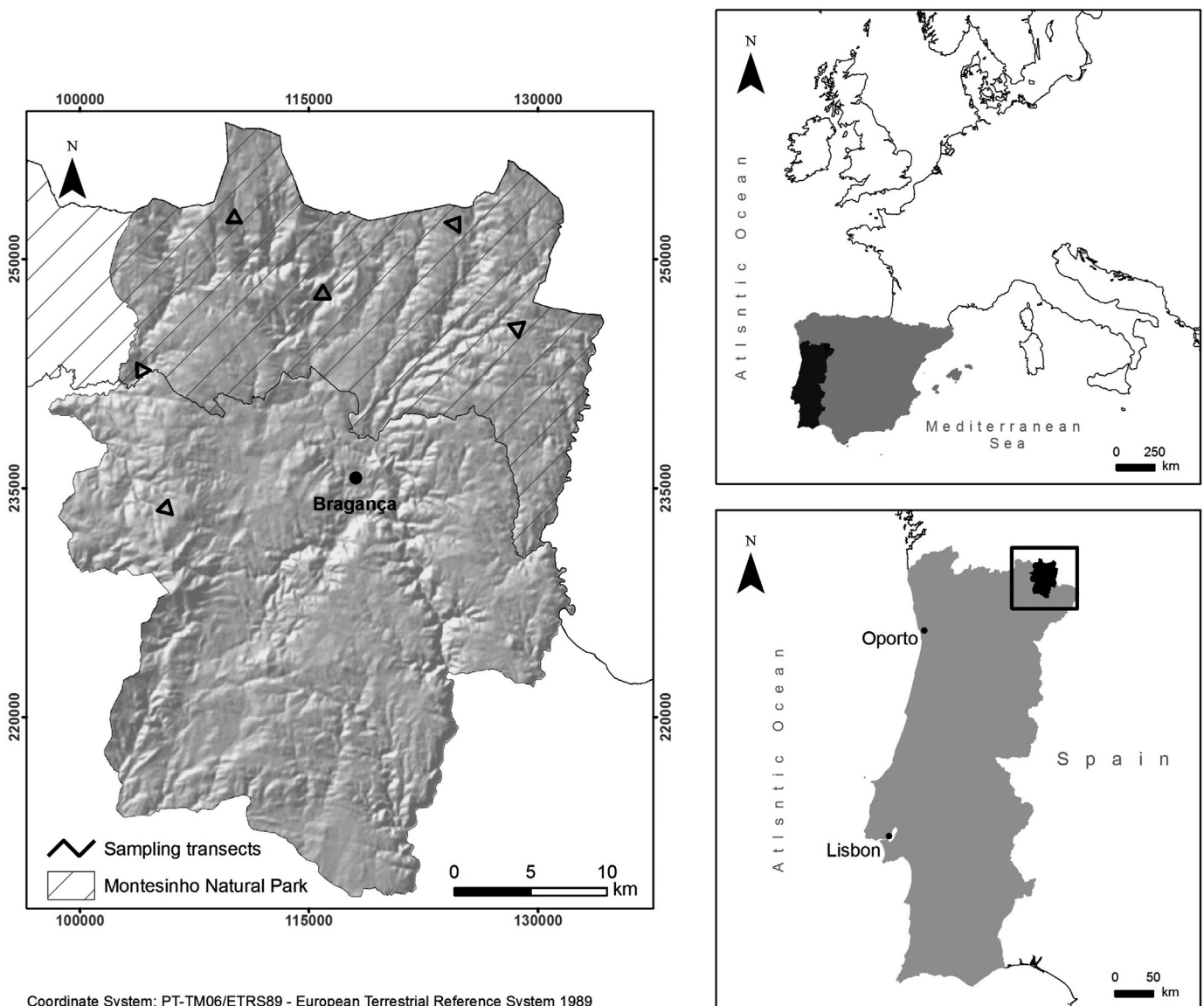


Fig. 1. Map of Portugal (right) highlighting the area where the field survey was done (Trás-os-Montes – right). On the left, there is the distribution of the sampling plots.

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