



## Supplemental feeding drives endoparasite infection in wild boar in Western Spain



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### ABSTRACT

Wildlife population management is thought to destabilize existing host–parasite equilibria in opposing directions, that is, it may increase parasite success or host resilience once infection takes place. This process is of special importance for species such as the wild boar (*Sus scrofa*) that are managed for game purposes throughout much of Europe. However, little is known about how this practice influences either gastrointestinal or pulmonary parasitism in the wild boar. Twelve hunting estates were chosen in order to study the relationship of management measures (feeder density, wild boar abundance, the ratio of wild boar per feeder and the percentage of sclerophyllous vegetation) and host factors (age and sex) with gastrointestinal and pulmonary parasite aggregation, richness, infection probability and intensity of infection. Parasitological analyses from 300 wild boar gastrointestinal and 269 respiratory tracts were performed for this purpose. A set of general linear models with combinations of the explanatory variables was built and the model with the smallest Akaike Information Criterion was selected as the best. The feeder density increased gastrointestinal parasite traits (richness, infection probability and intensity of infection), probably due to the contamination of feeding sites with infective parasite forms. Pulmonary parasite traits, on the other hand, were only influenced by host sex and age class, and parasite aggregation was as expected for a wild population. Managers should be aware of the consequences on parasitism when implementing supplemental feeding in hunting estates.

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### 1. Introduction

Game management is a widespread practice involving measures such as supplemental feeding, fencing

and translocation, and may play a role in maintaining pathogens in wild populations (Gortázar et al., 2006). For example, in east Africa the fencing of reserves for recreational hunting has been related to an increment in both nematode richness and prevalence in the impala (*Aepyceros melampus*, see Ezenwa, 2004a). In addition, supplemental feeding during winter favours the aggregation of elks (*Cervus elaphus*) in Greater Yellowstone, thereby increasing their exposure to gastrointestinal nematodes (Hines et al., 2007). However, other factors should be taken into

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account when attempting to understand the net effect of these management practices on the success of parasite infections: for example, an increase in the probability of nematode infection due to changes in host density could be compensated for by a reduction in host susceptibility caused by supplemental feeding (Vicente et al., 2007).

The wild boar (*Sus scrofa*), the commonest large game species in Europe, is an excellent model for exploring the effects of game management practices on parasite infections. In Spain, wild boar is exploited under a broad variety of management conditions that range from small fenced ranches of about 200 ha known as *cercones* (game reserves characterized by their high wild boar density reaching values of over 100 individuals/km<sup>2</sup>) to large unfenced game reserves covering several thousand hectares. These management practices result in a total bag of over 50,000 wild boars in the centre and south of the Iberian Peninsula per game season (Garrido, 2011).

Diseases caused by microparasites (e.g. bovine tuberculosis (Vicente et al., 2006), porcine Circovirus type 2 (Vicente et al., 2004) and Aujeszky's disease (Vicente et al., 2005)) are commonly associated with intensive game management practices in Spain. Although high nematode loads have been found in captive wild boar from other countries (Fernandez-de-Mera et al., 2003; Varga et al., 2005), few efforts have been made to determine the influence of game management on parasite dynamics in game regions in central Spain (Vicente et al., 2007). To our knowledge, only one study has attempted this: Acevedo et al. (2007) evaluated the effect of wild boar abundance and aggregation on the prevalence of lung nematode infection. This lack of information is especially important regarding gastrointestinal parasites.

Parasites have an impact on host reproduction, growth and survival, and therefore play a role in regulating populations. However, this role may be limited by parasite aggregation: in general, when most of the parasites are living in just a few heavily infected individuals, too many parasites are lost from the system by parasite-induced host mortality (Wilson et al., 2002).

Heterogeneities in parasite infections are determined by multiple factors including the differential exposure of individuals to parasitic infective stages and varying susceptibilities to parasites, both of which are likely to be influenced by game management practices.

Using samples from the gastrointestinal and respiratory tracts of hunter-harvested wild boar from twelve hunting estates in the Extremadura region (SW Spain) we aimed to explore the influence of management measures such as supplemental feeding, wild boar abundance and aggregation and habitat quality on several traits of gastrointestinal and pulmonary parasites (see Section 2). To summarize, we studied whether or not parasite aggregation, individual parasite richness and infection probability and intensity were affected by management conditions or whether, on the contrary, these parameters only depend on host factors such as sex and age.

Our predictions differed for gastrointestinal (hereafter, GI) parasites (aggregation, richness and infection probability and intensity) and pulmonary parasites due to their

contrasting life cycles. Briefly, we expected GI parameters to be affected by management measures, since their life-cycles are mainly direct and, as has been reported, supplemental feeding increases animal abundance around feeders (Geisser and Reyer, 2004) and host contact rates (Gompper and Wright, 2005), thereby enhancing parasite prevalence. On the other hand, the traits of pulmonary parasites may depend only on host factors (sex and age) given that their intermediate hosts (invertebrates) are influenced by environmental factors other than game management practices.

In addition to these main predictions, we also expected to find higher parasitic loads in males than in females (Poulin, 1996), owing to androgen-induced depression of both humoral and cell-mediated immune responses (Grossman, 1985); likewise, since the acquisition of immunity to helminthes is well-known to occur in domestic pigs (Pedersen and Saeed, 2001), we also expected to find lower nematode burdens in adults than in young wild boars.

## 2. Materials and methods

### 2.1. Study area

Our study area encompassed twelve hunting estates in the region of Extremadura (SW Spain), a typical Mediterranean landscape formed by hills less than 685 m.a.s.l. covered by oak forests (*Quercus* sp.), and *Cistus* sp. and *Erica* sp. scrublands (Fig. 1). The climate of the area is Mediterranean, with hot dry summers and mild winters. Annual precipitation averages 623 mm and is concentrated in November–April; mean annual temperatures reach 17.7 °C, being January and July the coldest and warmest months, respectively. Twelve hunting estates located in five different geographical areas (Cáceres, Monfragüe, San Pedro, Villuercas and Las Hurdes) were sampled during the 2004–2005 hunting season.

Certain management measures are common to all these hunting estates, for example supplemental feeding in summer (the period in which food is scarcest in Mediterranean ecosystems, see Bugalho and Milne, 2003). This activity is carried out in order to concentrate animals in the areas where they will be hunted and to avoid animal dispersion. An attractive feed such as maize is provided in feeders protected by metallic fences that ensure its access and availability for wild boar only (and not for other species e.g. red deer). Feeders were visited daily by gamekeepers and around 1 kg/animal/week of maize was provided during summer time. To our knowledge, no anthelmintic substance has ever been administered in the hunting estates involved in this study.

In addition, the chosen hunting estates do not employ any other typical management measures such as high-wire fencing or translocations of farm-bred or free-ranging wild boar from other hunting estates, a fact that conferred certain homogeneity on our results and allowed us to study the effect of supplemental feeding, habitat quality and abundance without interference from other management-related factors.

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