

Bronchopulmonary nematode infection of *Capra pyrenaica* in the Sierra Nevada massif, Spain

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ABSTRACT

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Cystocaulus ocreatus

Protostrongylus sp.

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The present investigation examined the prevalence and abundance of bronchopulmonary nematodes in 213 randomly hunted Iberian ibexes (*Capra pyrenaica*) (87 females and 126 males) in the Sierra Nevada mountain range in Spain between 2003 and 2006. Post mortem examination revealed an overall prevalence of 72% for adult nematodes (*Cystocaulus ocreatus* 44%, *Muellerius capillaris* 44%, *Protostrongylus* sp. 40%, and *Dictyocaulus filaria* 4%). The abundances were 13.45 ± 3.97 , 5.18 ± 2.49 , 6.36 ± 2.16 , and 2.27 ± 0.46 , respectively. Protostrongylid adults showed similar infection rates, which were statistically different from that of *D. filaria*. 20% of the examined Iberian ibexes were infected by three protostrongylid nematodes species, 24% of *C. pyrenaica* were affected by two protostrongylid species, while infestations with only one protostrongylid species were detected in 20% of the examined animals. The overall prevalence of larvae nematodes in the examined animals was 100%, and the overall abundance (number of the first stage larvae per gram) was 86.45 ± 20.63 . There was a high correlation between the two sets of data (adults and larvae). Results of the present investigation provided foundation for the effective control of bronchopulmonary nematode infection in Iberian ibex.

1. Introduction

Disease epidemics, overgrazing, uncontrolled hunting and progressive destruction of natural habitats play an important role in the marked demographic decline of the Iberian ibex (*Capra pyrenaica*) population. Although the

currently estimated population size (over 10,000 animals) of *C. pyrenaica* is still fairly large in the Sierra Nevada mountain range, the occurrence of severe demographic bottlenecks during the last two centuries is well documented (Manceau, 1997; Pérez et al., 2002).

Predicting the spread of wildlife disease is critical for identifying populations at risk, targeting surveillance and designing proactive management programmes (Julie et al., 2008). Lungworm infections are widespread among goats (Raynaud, 1977; Himmonas et al., 1980) and wild animals (Díez-Baños et al., 1990; Štefančíková, 1999; Štefančíková et al., 1999; Panadero et al., 2001; Hoby et al., 2006;

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Ramajo Martín et al., 2007) in Europe. Notwithstanding, to our knowledge, only one study reported bronchopulmonary infections in Iberian ibex with larval protostrongylids and *Dictyocaulus* spp. in Castilla La Mancha (Acevedo et al., 2005).

According to the literature, there is overwhelming evidence of controversial results concerning the factors (intrinsic: e.g. host age, sex and body weight, and extrinsic: e.g. temperature, rainfall, and forage availability) affecting the prevalence and abundance of bronchopulmonary nematode infections. Correlations between bronchopulmonary parasite load and host sex, age and body weight, different altitudes, geographic area, temperature (maximum and minimum), relative humidity, rainfall, forage availability and dry matter intake have been reported in different studies (e.g. Morrondo-Pelayo et al., 1992; Díez-Baños et al., 1994; Berrag and Urquhart, 1996; Nahed-Toral et al., 2003; Alemu et al., 2006; Jiménez et al., 2007). Controversially, no correlations or negative correlations have been described between parasite load and the factors mentioned above (e.g. Díez-Baños et al., 1990; Berrag and Urquhart, 1996; Nocture et al., 1998).

The objective of the present investigation was to examine prevalence and abundance of bronchopulmonary nematode infection in *C. pyrenaica* in the Sierra Nevada mountain range in Spain.

2. Materials and methods

2.1. Study area

The present study was conducted in the Sierra Nevada mountain range (36855^o–37810^oN, 2834^o–3840^oW). Altitudinal gradients of temperature and rainfall and all the bioclimatic stages described for Mediterranean climate are present.

2.2. The Sierra Nevada ibex population

The Sierra Nevada mountain range harbours one of the most important Iberian ibex populations with over 10,000 animals, which maintain a relatively high genetic variability (Pérez et al., 2002). Since the beginning of the 1990s, this population is affected by sarcoptic mange (*Sarcoptes scabiei*) and, mainly for this reason, it has been intensively monitored and managed. Domestic sheep, goats, cattle and, horses, in less proportion, are abundant in Sierra Nevada, particularly during summer months.

2.3. *C. pyrenaica* data

Between 2003 and 2006, 213 randomly hunted Iberian ibexes (87 females and 126 males) were transported to our laboratories for necroscopic examinations. The sex of the animals was identified by visual inspection and their age assessed by horn segment counts (Fandos, 1995). Iberian ibexes were divided into three age classes according to their allometric growth and skeletal development (Granados et al., 2001; Serrano et al., 2006): yearlings (1 < 2 year, n = 27), juveniles (2 year < age < 6 year, n = 114) and adults (> 6 year, n = 72).

2.4. Diagnostic procedures for bronchopulmonary nematodes

The respiratory tracts, including lungs and trachea, were recovered from each animal. The trachea and main bronchi were opened longitudinally with a pair of scissors, carefully examined and, after placing them under running water, the lavage was poured into a container to collect the adult worms and/or larvae present. A visual inspection of dorsal and basal edges of the lungs was carried out and the presence and distribution of verminous nodules were recorded. After that, the pulmonary parenchyma, in particular the affected areas, was dissected carefully under a dissecting microscope to extract adult nematodes. Finally, 24 randomly selected lungs were weighed, cut into small pieces and placed in 8–10 small bags. The Baermann–Wetzel method was used to assess the number of first stage larvae (L1) per gram (LPG). The L1 count was carried out using Favati or McMaster chambers. When the numbers of larvae were fewer than 100, all of them were identified (Švarc, 1984); if there were more larvae, approximately 30% of the collected larvae was studied (Panadero et al., 2001).

Permanent preparations of adult and L1 specimens were made with lactophenol–cotton blue and specific identification was based on the descriptions of Gerichter (1951) and van Wyk et al. (2004).

3. Results and discussion

Four bronchopulmonary adult species were identified, namely *Cystocaulus ocreatus* (54.01%), *Protostrongylus* sp. (24.45%), *Muellerius capillaris* (20.80%) and *Dictyocaulus filaria* (0.73%) (Table 1). Protostrongylid adults showed similar infection rates, which were statistically different from *D. filaria* ($p = 0.024$). 28.01% of the adult nematodes were males, while 71.99% of them were females. Acevedo

Table 1
Prevalence and abundance of bronchopulmonary nematodes of *Capra pyrenaica* in the Sierra Nevada massif, Spain.

Nematode species	Adults		Larvae	
	Prevalence	Abundance	Prevalence	Abundance (L1 per gram)
<i>Cystocaulus ocreatus</i>	44%	13.45 ± 3.97 (min = 2, max = 36)	100%	36.38 ± 13.20 (min = 0.36, max = 267.82)
<i>Protostrongylus</i> sp.	44%	6.36 ± 2.16 (min = 1, max = 24)	95.83%	16.37 ± 5.05 (min = 0.13, max = 86.29)
<i>Muellerius capillaris</i>	44%	5.18 ± 2.49 (min = 1, max = 29)	95.83%	36.15 ± 11.35 (min = 0.54, max = 245.85)
<i>Dictyocaulus filaria</i>	4%	2.27 ± 0.46 (min = 1, max = 6)	4.16%	0.36 L1/g (only one Iberian ibex was infected)
Overall	72%	37.07 ± 2.8 (min = 1, max = 98)	100%	86.45 ± 20.63 (min = 1.09, max = 372.5)

et al. (2005) found that protostrongylid larvae had similar infection rates as that of *Dictyocaulus* spp.

Four larvae nematode species were found, namely *M. capillaris* (47.99%), *C. ocreatus* (32.08%), *Protostrongylus* sp. (19.87%) and *D. filaria* (0.04%) (Table 1). There was a high correlation between the two sets of data (adults and larvae), $p = 0.36$.

20% of the examined animals were parasitized by the three protostrongylid species (*C. ocreatus*, *Protostrongylus* sp. and *M. capillaris*). 4% of the Iberian ibex were infected by *C. ocreatus* and *M. capillaris*. Two protostrongylid species, *C. ocreatus* and *Protostrongylus* sp., were found together in 12% of the studied *C. pyrenaica*. 8% of the lungs were affected by *Protostrongylus* sp. and *M. capillaris*. Infection with only one species (*C. ocreatus*, *Protostrongylus* sp. or *M. capillaris*) was detected in 20% of the animals.

The bronchopulmonary nematode profile in Iberian ibex revealed in the present study differed greatly from that reported in domestic and other wild animals from Spain (Díez-Baños et al., 1990, 1994; Panadero et al., 2001). These differences may be related to differences in host susceptibility (Berrag and Urquhart, 1996; Armour, 1980). The present survey showed a widespread incidence of multiple infections of bronchopulmonary nematodes in Iberian ibex from the Sierra Nevada mountain range involving four species, indicating that the climatic and ecologic conditions in the Sierra Nevada mountain range are favourable to protostrongylid infections (Cabaret, 1981). *Dictyocaulus* infection does not appear to be a serious problem, as confirmed by low levels of worm burdens. The longevity and development of free-living larvae of *Dictyocaulus* are known to be closely dependent on humidity and temperature conditions and the dry season is characterised by high mortality of larvae in pasture (Rose, 1955; Gallie and Nunns, 1976; Berrag and Urquhart, 1996).

The present investigation demonstrated that the prevalence and abundance of bronchopulmonary nematode infection in Iberian ibex in the Sierra Nevada Mountain range are severe, which provided relevant “base-line” data for assessing the effectiveness of control strategies against bronchopulmonary nematode infection in Iberian ibex.

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