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Parasitism and horn quality in male Spanish ibex (*Capra pyrenaica hispanica*) from Andalucía based on coprological analysis and muscle biopsy

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Abstract

A parasitological survey was performed on 51 adult male Spanish ibexes (*Capra pyrenaica hispanica*) from Málaga (Andalucía, Southern Spain) which were legally hunted during rutting season (October to December) in 2002 and 2003, in order to determine the health status of the ibex populations. Animals were classified according to horn quality and geographic location and their respective parasite levels were compared. Gastrointestinal and pulmonary (family Protostrongylidae) nematodes (order Strongylida), intestinal cestodes (family Anoplocephalidae: *Moniezia expansa* and *M. benedeni*) and intestinal coccidia (*Eimeria* spp) were detected by coprological analysis, and muscle protozoa (*Sarcocystis* spp) by muscle biopsy. A parasitism index (PI) was calculated for each animal and parasite group. A horn index (HI) was designed that classified animals into four categories: HI_1 (good), HI_2 (normal), HI_3 (poor) and HI_4 (very poor). There was a negative correlation ($R = -0.262$; $P = 0.062$) between the PI of lungworms (Protostrongylidae) and HI, high lungworm PIs corresponded with lower HI values (better horn characteristics). Linear correlations between arcsine transformed parasite counts and one principal component analysis (PCA) of horn measures were calculated. There was a correlation ($R = 0.30$; $P = 0.03$) between lungworm larval shedding (Protostrongylidae) and PCA for horn quality. High larval counts corresponded with high PCA values (better horn quality). The possibility of rut stress affecting dominant males is proposed as a predisposing factor for the observed trend.

Additional key words: coprological analysis; digestive, lung and muscle parasites; horn measurement index; index of parasitism; muscle biopsy.

Resumen

Datos sobre parasitismo y calidad del cuerno en machos monteses (*Capra pyrenaica hispanica*) de Andalucía según análisis coprológicos y biopsias musculares

Se realizó un estudio parasitológico con 51 ejemplares adultos de macho montés (*Capra pyrenaica hispanica*) del sur de España (Málaga, Andalucía) abatidos legalmente en temporada de celo (octubre a diciembre de 2002 y 2003), con el fin de conocer el estado sanitario de las poblaciones. Los animales se clasificaron según las medidas de los cuernos y su procedencia geográfica, comparándose los niveles de parasitación entre los distintos grupos. Se detectó parasitación por nematodos gastrointestinales y broncopulmonares (Protostrongylidae) del orden Strongylida, cestodos Anoplocephalidae (*Moniezia expansa* y *M. benedeni*) y protozoos intestinales (*Eimeria* spp.) mediante análisis coprológicos y *Sarcocystis* spp. mediante biopsias musculares. Se calculó un índice de parasitismo (PI) para cada animal y grupo parasitario y se clasificó a cada animal según morfometría del cuerno (HI) en cuatro categorías: HI_1 (buena), HI_2 (normal), HI_3 (mala) y HI_4 (muy mala). Se detectó una correlación negativa ($R = -0{,}262$; $P = 0{,}062$) entre el PI por Protostrongylidae y el HI, correspondiéndose los mayores parasitismos por broncopulmonares con los menores índices morfométricos (mejor conformación). Se calculó la correlación lineal entre las cargas parasitarias transformadas en seno hiperbólico inverso y el análisis de componentes principales (PCA) de las medidas de los cuernos, detectándose una correlación estadística ($R = 0{,}30$; $P = 0{,}03$) para los protostrongílidos. Se sugiere la posibilidad del estrés del celo otoñal en los machos dominantes como factor predisponente en la tendencia observada.

Palabras clave adicionales: análisis coprológico; biopsia muscular; índice morfométrico del cuerno; índice de parasitismo; parásitos broncopulmonares, digestivos y musculares.

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Introduction

The Spanish ibex (*Capra pyrenaica*) is a wild goat only found in the mountains of Spain. Only two of four original subspecies of Spanish ibex (*Capra pyrenaica hispanica, C. p. victoriae, C. p. lusitanica* and *C. p. pyrenaica*) (Cabrera, 1911) still exist. *Capra pyrenaica lusitanica* became extinct last century and the last specimen of *C. p. pyrenaica* disappeared from the Spanish Pyrénées in January 2000 (Granados *et al*., 2001). Granados *et al*. (2001) estimated the total population of Spanish ibex is 49,560 animals, with some 9,150 animals being the *C. p. victoriae* subspecies and 40,410 being *C. p. hispanica*. Most (>75%) of the animals of the *C. p. hispanica* subspecies are located in Andalucía in southern Spain.

Like other highly polygamous ungulates, Spanish ibex males develop large horns for intra-sexual competition. Horn size is correlated with male dominance and fighting ability and consequently potential lifetime reproductive success (Clutton-Brock *et al*., 1988). At nine years of age the horns are nearly fully developed (Fandos, 1995) and the animals are therefore most valuable from a game sport point of view.

As a complement to a reproductive study carried out with several populations of Spanish ibexes from Málaga, in Andalucía (Santiago-Moreno *et al.,* 2007; Toledano-Díaz *et al.,* 2007), the level of parasitism, based on coprological analyses of fully developed males was investigated, to determine their health status. The animals were classified according to horn quality and geographic location and their respective parasite levels were compared.

Material and Methods

Study area

Tejeda y Almijara National Game Reserve is a 204 km^2 wildlife reserve located in southern Spain (Málaga, 36° 45'- 36° 56' N; 3° 46'- 4° 6' W). This game reserve extends from the Málaga sea coast into the surrounding mountains, with the Maroma (2,068 masl) being the highest peak. At sea level the landscape is dominated by Mediterranean fan palm (*Chamaerops humilis*); olive trees (*Olea europaea*), carob (*Ceratonia siliqua*) and Aleppo pine (*Pinus halepensis*). As elevation rises, in transition areas, Portuguese oak (*Quercus faginea*), maritime pine (*Pinus pinaster*) and prickly juniper (*Juniperus oxycedrus*) predominate. Finally, in the mountainous areas there are oak (*Quercus pyrenaica*), common yew (*Taxus baccata*), European black pine (*Pinus nigra*) and Scots pine (*Pinus sylvestris*).

The climate is Mediterranean with mild winters and hot summers, it is cooler in the interior (northern) than on coastal (southern) hillsides- (mean winter temperatures of 7.5°C to 13.5°C; and mean summer temperature of 21°C to 24°C). Annual rainfall gradually decreases from inland (Alcaucín, 990 mm) to coastal (Nerja, 425 mm) areas.

Spanish ibex populations

In recent years, a predetermined number of Spanish ibex in the Tejeda y Almijara National Game Reserve have been legally culled and hunted during rutting season. This hunting management is oriented towards equilibrating the sex ratio and age structure of the population by selective hunting of females and males, including trophy bucks, and males with poor quality horns. At present, the estimated number of animals in this game reserve is 1,150 (<6 animals 100 ha^{-1}), with a sex ratio of 1:1. Natural predators of ibex kids, in the reserve, are golden eagle (*Aquila chrysaetos*) and red fox (*Vulpes vulpes*). Several herds of domestic goats have free access to the mountain pastures of the reserve during the day. Precise data on the census, sex ratio and natural predators were provided by Management Services of the Tejeda y Almijara National Game Reserve (Environmental Council, Junta de Andalucía).

Sampling

The study was carried out on 51 adult males (9 to 15 years of age) legally hunted during the rutting season (October to December) in 2002 and 2003. The age of the ibexes was determined from their horns (growth marks) (Fandos, 1995).

Abbreviations used: AB (asymmetry between horn bases), AL (asymmetry between horn lengths), BPN (bronchopulmonary nematodes), cps (cysts animal $sample^{-1}$), epg (eggs g^{-1}), FS (significant factor), GIN (gastrointestinal nematodes), HB (horn base perimeter), HI (horn index), HL (horn length), HQ (horn quality), lpg (larvae g^{-1}), masl (meters above sea level), opg (oocysts g^{-1}), PCA (principal component analysis), PI (parasitism index).

Hunting occurred in four locations, from inland (northern and more humid) to the coast (southern and drier): Alcaucín (zone 1), Sedella (zone 2), Cómpeta-Canillas de Albaida (zone 3) and Nerja (zone 4).

Horn measurements

Horn measurements were taken on both horns. After death, outer horn length (distance from the outer horn-skull junction to the end of the horn) and horn base circumference around the horn-skull junction were measured with a measuring tape. For both measurements (length and base perimeter), relative asymmetry was calculated using the formula of Maylon and Healy (1994):

$$\text{Asymmetry} = |(l - r)| / (l + r),$$

where l = measurement from the left horn, r = measurement from the right horn.

Based on expected horn length (HL) for 9-year old goats were classified as in Fandos and Vigal (1988): L_1 (HL ≥ 60 cm, normal horn length), L_2 (H = 0-59 cm, short horn length) and L_3 (HL < 50 cm, very poor horn length). Based on base perimeter measures (HB), horns were classified as B_1 (HB ≥ 20 cm, normal) or B_2 (HB < 20, poor condition).

Using these measures, the horn quality (HQ) was calculated for each animal as the sum of the values assigned to length (L = 1, 2 or 3), base perimeter (B = 1 or 2) and the asymmetry between the respective lengths (AL) and bases (AB) of the left and the right horns:

$$HQ = L + B + AL + AB$$

Based on the resulting HQ, animals were categorized into one horn index (HI): HI_1 (HQ = 2, good horn condition), HI_2 (HQ > 2-3, normal horn condition), HI_3 (HQ > 3-4, poor condition), and HI_4 (HQ > 4, very poor condition).

Post mortem collection

All samples taken for the parasite study were collected during the first hour after death. Total solid rectal faeces and a portion (ca. 3 × 6 cm) of the sinew part of diaphragm were collected from each animal.

Faecal and muscle samples were placed in separate plastic flasks and transported at 10°C to a local laboratory (located in zone 2). At the laboratory, faecal samples were refrigerated. Diaphragm samples were stored at –20°C. All samples were sent by express delivery to the laboratory of the Department of Animal Health, Veterinary Faculty, Madrid between 24 and 48 hours post-collection. Faeces were analyzed immediately and muscle samples were stored in glycerine-ethanol (70% ethanol in glycerine) until analysis.

Parasitological analyses

Coprology

Three grams of faeces were analyzed by flotation (modified McMaster method; Laboratorio Central Veterinario Weybridge, 1973) with 50% zinc sulphate (δ = 1.3) as a polyvalent method for structures of lower density such as eggs of gastrointestinal nematodes (GIN: Strongylida, Rhabditida, Trichuroidea), cestodes (Anoplocephalidae) and oocysts of intestinal coccidia (*Eimeria* spp.) and denser ones like eggs of hepatic trematodes (*Fasciola hepatica, Dicrocoelium dendriticum*). Ten grams of faeces were analyzed by the Baermann-Wetzel method (MAFF, 1977) for first-stage larvae of lung nematodes (Dictyocaulidae and Protostrongylidae). Microscopic identification and counting were carried out in McMaster chambers following MAFF (1977) instructions. Counts were expressed as eggs g^{-1} (epg), oocysts g^{-1} (opg) and larvae g^{-1} (lpg) of faeces.

Muscle biopsy

Fourteen diaphragm slides, the size of a grain of rice, were pressed between glass plates and observed under a compound microscope (×40-100) for *Sarcocystis* spp. cysts, following the trichinoscopy technique in Directive 77/96 ECC, Anex I, for pork meat examination (EEC, 1977). Counts were expressed as cysts animal sample^{-1} (cps).

Parasitological indexes

The prevalence, individual intensity and mean intensity were calculated for each parasite group (GIN, cestodes, trematodes, coccidia, lungworms) according to Margolis *et al.* (1982).

For each animal a parasitism index (PI) was calculated for each parasite group (PI = individual intensity/mean intensity). The total PI for each animal was obtained by summing the respective partial indexes ($\sum$PI).

Statistical analyses

The possible links between parasite counts and horn measurements were analyzed by two linear correlation (Pearson) analyses: one between parasite counts for each parasite group and the variable generated by «one principal component analysis» (PCA) performed on the three horn measures (relative asymmetry, outer horn length, and base perimeter), which gave a significant factor score (FS horn quality), and the other between the respective PIs and horn quality (HQs). For the first linear correlation, as the parasite counts had a skewed distribution (Shapiro-Wilk's test: $P < 0.05$), they were arcsine transformed before statistical analysis.

To discard the possibility of errors produced by heterogeneity of geographic areas, differences among PIs or HQs, according to hunting area (zones 1, 2, 3 and 4), were tested by one way-ANOVA.

Differences in parasite prevalence according to HIs were analyzed by χ^2 test. Comparisons among the prevalence of parasites, according to hunting area, also used the χ^2 test.

All statistical procedures were performed with the Statistica® 6.0 Software for Windows. Results were considered significant when $P \leq 0.05$.

Results

The mean horn measurement of the population was of 53.8 cm (± 10.56 standard deviation) for length and 19.5 cm (± 1.63 standard deviation) for base perimeter.

Animals from each hunting area were categorized as follows:

— Zone 1: $HI_1 = 0$ animals; $HI_2 = 2$ animals; $HI_3 = 4$ animals; $HI_4 = 3$ animals.

— Zone 2: $HI_1 = 0$ animals; $HI_2 = 3$ animals; $HI_3 = 2$ animals; $HI_4 = 3$ animals.

— Zone 3: $HI_1 = 6$ animals; $HI_2 = 8$ animals; $HI_3 = 8$ animals; $HI_4 = 2$ animals.

— Zone 4: $HI_1 = 0$ animals; $HI_2 = 3$ animals; $HI_3 = 4$ animals; $HI_4 = 3$ animals.

— All animals with good horn quality (HI_1) were from zone 3 (Canillas de Albaida-Competa).

Overall parasite data are shown in Table 1. Four parasite groups were detected by faecal analysis: gastrointestinal nematodes (GIN) (order Strongylida), intestinal cestodes of the family Anoplocephalidae (*Moniezia expansa* and *M. benedeni*), intestinal coccidia (*Eimeria* spp.), and bronchopulmonary (BP) nematodes of the family Protostrongylidae (order Strongylida). Larvae of the genus *Dictyocaulus* were not detected. Protozoa of the genus *Sarcocystis* were found by muscle biopsy. Bronchopulmonary nematodes were most prevalent (100%). The four genera of Protostrongylidae (*Muellerius*, *Neostrongylus, Cystocaulus* and *Protostrongylus*) were identified. Among digestive parasites, the highest prevalence was of GIN (88%) and the lowest was cestodes (< 6%). Larval counts of BP nematodes were essentially low or moderate, but excretions were important (> 350 lpg) in 15% of the animals, some of them reaching very high levels ($> 10^3$ lpg in three animals). Animals with high lpg excretions were proportionally more numerous in zone 3 (21%) than in zones 1 (11%), 2 (12%) or 3 (10%). The highest lpg excretions were detected in zone 3. Faecal egg counts of GIN were essentially low or moderate (≤ 250 epg), in 74% of the animals, but counts were high (250-500 epg) in 24% of the animals (29% of animals from zone 1; 22% of

Table 1. Intensity (average ± standard deviation) and prevalence of parasitism detected in 51 adult male Spanish ibex legally hunted during the rutting season (October to December) in 2002 and 2003

	n	x ± sd (min-max)	Prevalence (N = 51)
GIN (Strongylida), epg[1]	45	168.2 ± 143.8 (5-600)	88.2%
Cestodes (*Moniezia*), epg[1]	3	183.3 ± 76.4 (100-250)	5.9%
Coccidiae (*Eimeria*), opg[2]	31	268.2 ± 248.6 (15-950)	60.8%
BPN, lpg[3]	51	241.0 ± 363.4 (4-2,373)	100%
Muscle Protozoa (*Sarcocystis*), cps[4]	12	2.7 ± 3.3 (1-10)	23.5%

[1] GIN: gastrointestinal nematodes; epg: eggs g^{-1} faeces. [2] opg: oocysts g^{-1} faeces. [3] BPN: bronchopulmonary nematodes (Protostrongylidae), lpg: larvae g^{-1} faeces. [4] cps: cysts animal $sample^{-1}$.

zone 2; 25% of zone 3; 10% of zone 4) and very high (600 epg) in one animal from zone 2. Oocyst counts of coccidia were very low ($<10^3$ opg) in all cases. Muscle cysts, of the genus *Sarcocystis,* were present in about 23% of the animals with a low intensity (1-10 cysts $sample^{-1}$). No age effect was observed on excretion in any parasite group, highest excretions were observed in animals of 9 to 14 years. Most animals with high lpg or epg excretions were parasitized by both BP and GI nematodes and by *Eimeria* spp.

The prevalence of parasites in each parasite group were calculated for each HI. There was no statistical differences in prevalence of the four HI groups in any parasite group.

The linear correlations between PIs and HQs for each parasite group are shown in Figure 1, which shows the mean PI of each of the four HIs for each parasite group. None of the correlations were statistically significant. There was a negative correlation, which was not quite significant (R = –0.26; P = 0.06), between the PI of BP nematodes (Protostrongylidae) and HQ, with higher larval counts corresponding to better horn quality.

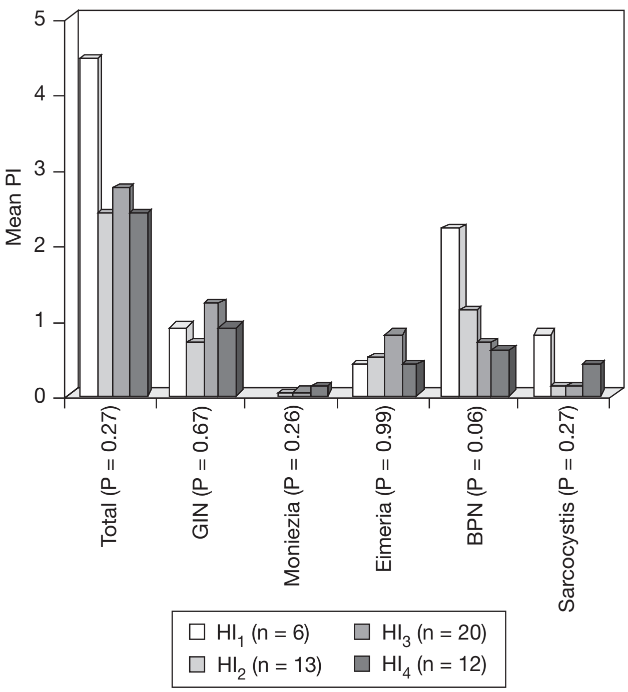

Figure 1. Linear correlations between parasitism indices (PI) and the horn indices (HI) for each parasite group (statistical significances in brackets). GIN: gastrointestinal nematodes. BPN: bronchopulmonary nematodes. Bars represent the mean PI for each parasite group and for the total PI according to HI.

Table 2. Linear correlations between arcsine transformed parasite counts and PCA (one principal components analysis) of horn measures for each parasite group

Parasitic group	Correlation coefficient (R) (N = 51)	Anova test (d.f. = 49)
GIN (Strongylida)	0.25	P = 0.85
Moniezia	–0.12	P = 0.37
Eimeria	0.14	P = 0.30
BPN	–0.30	P = 0.02
Sarcocystis	–0.18	P = 0.89

GIN: gastrointestinal nematodes. BPN: bronchopulmonary nematodes (Protostrongylidae). d.f.: degrees of freedom.

The linear correlations between arcsine transformed parasite counts and the PCA for horn quality are shown in Table 2. There was a correlation (R = 0.30; P = 0.03) between larval shedding of BP nematodes (Protostrongylidae) and the PCA for horn quality, higher larval counts corresponded with higher PCA values (better horn quality).

Differences among PIs, and in parasite prevalence, according to hunting areas were tested and were not statistically significant (Table 3). Differences among HIs by hunting area were highly significant (P = 0.08) when comparing the four zones (1, 2, 3 and 4) but not when comparing zones 1, 2 and 4 (P = 0.43).

The linear correlations between PI and HI and between arcsine transformed parasite counts and the PCA for horn quality were retested excluding animals from zone 3. There were no significant correlations. The same analysis were made only for animals in zone 3 and a correlation pattern (R = 0.36) between parasite counts and horn quality, with a nearly significant trend (P = 0.059), was detected for the protostrongylid nematodes.

Discussion

Mean horn lengths, in this population, were shorter that those observed in other ibex populations (Granados *et al.,* 1997). This may be related to specific environmental conditions in this game reserve together with habitat fragmentation. In fact, in Spanish ibex horn size has been used to estimate differences among populations (Fandos and Vigal, 1988).

Although the results indicate a generally moderate degree of infection in adult ibexes, protostrongylid and gastrointestinal nematodes excretion was high in some

Table 3. Statistical differences calculated among parasitism indices (PI) according to hunting areas (zones 1, 2, 3, 4) tested by one way-ANOVA (confidence level = 95%). Respective prevalence in brackets (statistical differences are tested by χ^2 test; confidence level = 95%)

	GIN	*Eimeria*	BPN	*Sarcocystis*	*Moniezia*
Zone 1 PI (x ± sd)	0.7 ± 0.7	0.8 ± 0.8	0.7 ± 0.4	0.04 ± 0.1	
N = 9	n = 6	n = 7	n = 9	n = 1	n = 1
Prevalence (%)	(66.6%)	(77.8%)	(100%)	(11.1%)	(11.1%)
Zone 2 PI (x ± sd)	0.8 ± 0.7	0.4 ± 0.4	0.7 ± 0.6	0.6 ± 1.3	
N = 8	n = 8	n = 4	n = 8	n = 2	n = 0
Prevalence (%)	(100%)	(50%)	(100%)	(25%)	(0%)
Zone 3 PI (x ± sd)	1.0 ± 0.8	0.8 ± 1.0	1.4 ± 2	0.2 ± 0.8	
N = 24	n = 22	n = 17	n = 24	n = 5	n = 2
Prevalence (%)	(91.7%)	(70.8%)	(100%)	(20.8%)	(8.3%)
Zone 4 PI (x ± sd)	0.5 ± 0.7	0.2 ± 0.2	0.6 ± 0.6	0.2 ± 0.2	
N = 10	n = 9	n = 3	n = 10	n = 5	n = 0
Prevalence (%)	(90%)	(30%)	(100%)	(50%)	(0%)
ANOVA test (P)	P = 0.30	P = 0.19	P = 0.35	P = 0.57	
χ^2 (P)	P = 0.14	P = 0.09	P = 1	P = 0.21	P = 0.60

GIN: gastrointestinal nematodes. BPN: bronchopulmonary nematodes (Protostrongylidae).

animals. The intensity of parasitism of direct cycle species should be low in the wild, providing that the host population density is under tolerable limits. This would explain the predominantly moderate excretion detected in the study for direct cycle parasites like gastrointestinal nematodes (GIN) from the order Strongylida, taking into account the low ibex population density of the game reserve, despite the potential pasture contamination source from domestic goats. The level of excretion of GIN detected in our study, including those which would be classified as high in domestic sheep or goats, were similar to those reported by Lavin *et al*. (1997) for asymptomatic ibexes hunted in coastal north-eastern Spain, and 100 times lower than those observed by the same authors in two animals which died from acute haemorrhagic anaemia due to haemonchosis. According to Lavin *et al*. (1997), epizootics of haemonchosis in ibexes from the north-east coast of Spain occurred when the population density was very high, usually more than 30 animals 100 ha^{-1}. Another factor related to the infection by strongylid GIN is acquired immunity, which makes animals highly resistant after several grazing seasons (Urquhart *et al*., 1987). The adult age of the animals would also account for the moderate excretion levels observed here. Nevertheless, the high infection prevalence detected and the high excretion levels, shown by some animals indicates that parasitism by GIN is epidemiologically important in the reserve and should be considered as a potential disease risk for younger, more susceptible animals, in case of increased ibex population density.

The same circumstances would account for other direct cycle intestinal parasites such as *Eimeria* spp., whose importance in domestic animals is strongly linked to intensive breeding. The low population density and the high resistance of adult animals to coccidial infections, due to acquired immunity, explain the low excretion level of oocysts in adult ibexes in this study.

As for parasitism by heteroxenous parasites such as Plathyhelminthes, the adult age of the animals would also explain the low prevalence of infection by *Moniezia* spp., given the strong resistance acquired, to these species of tapeworm, with the host age (Soulsby, 1982; Ramajo Martín and Muro Álvarez, 1999). Our results on *Moniezia* spp. are similar to those reported for Spanish ibexes from Andalucía by Granados *et al*. (2001). Other heteroxenous parasites detectable by faecal analysis such as Trematoda (*Fasciola, Dicrocoelium, Paramphistomum*) were not observed in this study using a 50% zinc sulphate flotation technique. Granados *et al*. (2001) reported the prevalence of Trematoda in Andalucian Spanish ibex was very low.

As for muscle protozoa, *Sarcocystis* spp are the most widespread tissue parasite of domestic and wild herbivores worldwide. Studies in the Italian Alps, showed ibex was an intermediate host for, at least, four *Sarcocystis* species including the cosmopolitan species of domestic goats *S. capracanis,* whose morphotype is the most commonly observed in ibex (Cornaglia *et al*., 1998). Definitive hosts of the majority of ungulate *Sarcocystis* spp. are predators of the Canidae family, whose abundance in an area is probably the conditioning ecological factor for the prevalence of sarcocystosis (Malakauskas and Grikienienė, 2002). In the game park of our study, definitive hosts would be foxes as well as shepherd and hunting dogs. Our findings on parasitism of Spanish ibex by *Sarcocystis* spp. agree with previous results from the same geographic region (Granados *et al*., 2001), which showed moderate levels of prevalence compared with the high indices reported for alpine ibex in Italy (Cornaglia *et al*., 1998) and for other wild ruminants such as red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) in Germany (Erber *et al*., 1978), Poland (Tropilo *et al*., 2001), Lithuania (Malakauskas and Grikienienė, 2002) and North-west Spain (López *et al*., 2003). The intensity of sarcocyst infection, in our study, was low in all animals.

The highest infection prevalence was bronchopulmonary nematodes (BPN) of the family Protostongylidae. It was detected in all animals. A high prevalence of BPN in this species, from the same geographic area, was reported by Cano *et al.* (1996). The most remarkable finding in our study was the high level of protostrongylid larval excretion observed in some animals, compared with their observations in Spain for Spanish ibex (Gortazar *et al*., 2005) and other wild ruminants like mouflon (*Ovis musimon*) (Meana *et al*., 1996) and roe deer (Panadero *et al*., 2001). These high levels of larval excretion and the presence of Prostostrongylidae in all animals studied confer a great epidemiological importance to this parasite group in the area.

There was a statistically significant correlation between the degree of parasitism by small lungworms (Protostrongylidae) and horn quality, the highest numbers of protostrongylid larvae were observed in the best horned males from zone 3. These high larval excretions, could have responded to a temporary increase in larval output due to reactivation of arrested larvae. This phenomenon is well documented for *Cystocaulus ocreatus* (Borchert, 1981). Third stage larvae, of this species, can arrest their development in the lungs for more than 300 d, to be reactivated until sexual maturity when the definitive host is affected by adverse factors. Under natural conditions the bulk of inhibited larvae would remain ready to resume development, under certain circumstances, such as a temporary weakening of the host's immune status. A related phenomenon could be a periparturient rise of lungworm larval output, attributable to a temporary relaxation of immunity due to hormonal changes, comparable to that observed in gastrointestinal strongyles in lactating ewes, which has been described in domestic goats (Berrag and Urquhart, 1996). The stress suffered by dominant Spanish male ibexes during the rutting season could have induced a temporary relaxation of immunity which would help explain the trend observed in this study.

A relationship between parasitism and stress deprived immunity has been detected in wild ruminants in other host-parasite systems. Smith (1998) reported similar observations on male elks (*Cervus elaphus*), which died of natural causes in North America. He observed that animals clinically affected by psoroptic mange (*Psoroptes* sp.) had better antlers than those which were apparently free of parasites. There was a positive correlation between antler development, *Psoroptes* infestation and host age. Smith (1998) suggested that males with better antlers, potentially dominant over other less qualified males, would suffer more stress during the rutting season and eventually grow weaker an be exposed to clinical mange more than animals with poorer antlers.

In our study, gastrointestinal strongyles did not show increased egg output comparable to that observed with lungworm larvae in dominant males. However, it is possible that the age of the animals prevented this phenomenon. Reinfections do not confer resistance to protostrongylids; they therefore increase the prevalence and worm burdens of these nematodes with the host age. Adult ruminants become highly resistant to gastrointestinal strongyles after several reinfections, as indicated by Urquhart *et al*. (1987).

A linear correlation between horn quality and lungworm larval output was only observed when the best qualified animals (HI_1) were included in the analysis and was not when they were excluded. This suggests that this group could be the one most significantly affected by stress. Curiously, these best horned animals were all hunted in zone 3 (Canillas de Albaida) although, according to the gamekeepers, animals in the reserve move freely among nearby areas. Nevertheless, no significant difference in parasite level or prevalence was detected among the four hunting grounds. This allowed us to ignore possible bias caused by the climatic differences between the northern-inner and southern-coastal areas. However, despite the absence of statistical significance, the drier climate, which characterizes the coastal area of Nerja, could have accounted for the lower lpg, epg and opg excretions of animals hunted in that area.

These results suggest that the higher shedding of protostrongylid larvae could respond, among other explanations, to a temporary relaxation of immunity in dominant males. The main implication of that, from an animal health point of view, would be that dominant males could become more susceptible to diseases than other animals during the rutting season.

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