POTENTIAL PATHOGENS CARRIED BY SPANISH IBEX (CAPRA PYRENAICA HISPANICA) IN SOUTHERN SPAIN

Authors: González-Candela, Mónica, Cubero-Pablo, María José, Martín-Atance, Pablo, and León-Vizcaíno, Luis

Source: Journal of Wildlife Diseases, 42(2) : 325-334

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-42.2.325

Journal of Wildlife Diseases, 42(2), 2006, pp. 325–334

POTENTIAL PATHOGENS CARRIED BY SPANISH IBEX (*CAPRA PYRENAICA HISPANICA*) IN SOUTHERN SPAIN

Mónica González-Candela,[1,3] María José Cubero-Pablo,[1] Pablo Martín-Atance,[2] and Luis León-Vizcaíno[1]

[1] Enfermedades Infecciosas, Departamento de Sanidad Animal, Facultad de Veterinaria, Universidad de Murcia, Campus de Espinardo, 30100 Murcia, Spain
[2] Centro de Investigación Agraria Albaladejito. Carretera Toledo-Cuenca, Km. 174. Cuenca, Spain
[3] Corresponding author (email: monica@um.es)

ABSTRACT: The Spanish ibex (*Capra pyrenaica hispanica*) population of southern Spain was surveyed for potential pathogens associated with the conjunctiva, external ear canal, as well as reproductive and upper respiratory tracts. We sampled 321 ibex (131 adult males, 100 adult females, and 90 yearlings); these included 271 apparently healthy animals and 50 that were naturally infected with *Sarcoptes scabiei*. A total of 688 bacterial isolates were identified (377 gram-negatives, 225 gram-positives, and 86 *Mycoplasma* spp.); sex, age, location, infection with *S. scabiei*, and disposition of the animal (free-ranging versus captive) were evaluated as risk factors for infection. Infections with *Mycoplasma agalactiae* and *Mycoplasma arginini* were associated with age, having a higher frequency of isolation in young animals. With *Escherichia coli, Mannheimia haemolytica, Pasteurella multocida* biotype A, and *Staphylococcus aureus*, significantly higher isolation rates were associated with adults. The isolation frequency for *E. coli* was higher in females, whereas *Moraxella bovis* isolations were mostly associated with males. The presence of mange increased the risk of infection with both *Streptococcus equi* subsp. *zooepidemicus* and *M. haemolytica*. The geographic origin of sampled animals was related to the isolation of *Branhamella ovis*, *M. agalactiae,* and all *Pasteurella* sp. Isolations of *M. haemolytica, P. multocida* biotype A, *E. coli,* and *B. ovis* were more prevalent in samples from free-ranging rather than captive animals. Of the gram-positive bacteria, *S. aureus* represented the predominant species isolated from nasal, vaginal, and ocular samples. *Mycoplasma agalactiae* and *M. arginini* were the predominant *Mycoplasma* spp., and both were associated most often with the external ear canal. The most frequently isolated gram-negative bacteria included *E. coli, M. haemolytica*, *P. multocida* biotype A, and *B. ovis*. Isolation rates of gram-negative species varied by source. In nasal samples, *M. haemolytica* and *P. multocida* biotype A were isolated most frequently, whereas in ocular and vaginal samples, *B. ovis* and *E. coli,* respectively, were most frequently isolated.

Key words: Bacteria, *Capra pyrenaica hispanica*, external ear canal, ocular mucosa, reproductive tract, Spanish ibex, upper respiratory tract.

INTRODUCTION

The Spanish ibex (*Capra pyrenaica hispanica*) is the only native, free-ranging, wild caprine in Spain and is found throughout the massifs of the southern and eastern portions of the country (Fandos, 1991). The populations in Andalusia, with an estimated 30,000 individuals in 34 massifs, have been studied by Pérez et al. (2002). Densities vary over occupied habitats, with approximately half of these animals occupying areas where no conservation measures are in place and populations are often fragmented. Problems have occurred, or have been anticipated, associated with local overabundance, disequilibrium in the population sex ratios and age structure, and loss of genetic diversity. An important disease associated with high-density populations is sarcoptic mange (Palomares and Ruiz-Martínez, 1993; Pérez et al., 1997; León et al., 1999). Although other infectious agents may be involved in these epidemics, information regarding the presence of other potentially pathogenic agents in Spanish ibex is limited. Spanish ibex also seasonally share pastures with domestic small ruminants, which may enhance pathogen transmission (Pérez et al., 2002). The objectives of the present study were to improve the understanding of bacterial pathogens potentially affecting Spanish ibex and to evaluate potential risk factors associated with these infections.

MATERIALS AND METHODS

The study was conducted on a population of free-ranging Spanish ibex in the massifs of southern Spain. Samples were collected from 321 animals in different provinces of Andalusia: 111 (34.6%) from Granada (3.35 W/37.11 N; Sierras de Nevada, Tejeda, and Loja), 105 (32.7%) from Málaga (4.250 W/36.43 N; Sierras de Ortegicar, Aguas, Camarolos, Peñarrubia, Ronda, Madroño, and Tejeda Almijara), 63 (19.6%) from Almería (2.280 W/36.50 N; Sierras de Nevada, Laujar, Gador, and Contraviesa), 31 (9.7%) from Jaén (3.470 W/37.46 N; Sierra de Cazorla), and 11 (3.4%) from Cádiz (6.18 W/36.43 N; Sierras de Líjar, Los Alcornocales, and Grazalema). These included animals that were selectively hunted (60.3%), live-captured (24.9%), captive-bred (9.3%), game-hunted (4.0%), and found dead (1.5%). The sample included 135 females (35 yearlings [<1 yr], 14 juveniles [1–2 yr], 17 subadults [3–4 yr], and 69 adults [>4 yr]) and 186 males (55 yearlings, 12 juveniles, 43 subadults, and 76 adults).

Animals were sampled over a 2-yr period from October 1996 to October 1998. Nasal, ear, and ocular swabs were collected from all animals, and vaginal samples were collected from females. Among sampled ibex, 271 (84.4%) were apparently healthy (no visible lesions on external inspection), and 50 (15.6%) were naturally infected with *Sarcoptes scabiei*.

Nasal, ocular, ear, and vaginal samples were collected with sterile swabs using Amies medium with charcoal (Ventury Transystem, Copan, Bovezzo, BS), refrigerated at 4 C, and sent to the Infectious Diseases Laboratory of the Veterinary Medicine Faculty in Murcia University. Samples were analyzed within 72 hr of collection.

Swabs from the nasal, ocular, and vaginal mucosa were cultured directly on Columbia Blood agar with 5% sheep blood (bioMérieux, Marcy-l'Etoile, France) and McConkey agar (Merck and Co., Darmstadt, Germany) and incubated at 37 C in an atmosphere containing 5% CO_2. Culture plates were examined for bacterial growth after 24 and 48 hr of incubation. Samples also were inoculated into selective salmonella-enriching broths (tetrationate broth and Rappaport, Merk, Darmstadt, Germany), incubated for a maximum of 48 hr, and then plated on a selective solid media (agar with xylose, lysine, and desoxycholate, Difco Laboratories, Detroit, Michigan, USA), brilliant green (Oxoid, Fisher Scientific International Inc., Basingstoke, Hampshire, UK), and McConkey agar (Difco Laboratories) by drip-feed from each tube of enriching broth. These cultures were incubated at 37 C in aerobic conditions for 48 to 72 hr, and plates were observed every 24 hr for colonies growth.

An isolated colony representing each bacterial variant was selected and identified following the methods of *Bergey's Manual of Systematic Bacteriology* (Krieg and Holt, 1984; Sneath et al., 1984). In addition, the Rapid PASCO (Soria Melguizo, Madrid, Spain) and API System (NH, Staph, Strep, 20e, 20ne strips, bioMérieux, Marcy-l'Etoile, France) were used to identify gram-positive and gram-negative isolates.

For mycoplasma culture, ear and ocular swabs were directly inoculated in selective modified Hayflick solid and liquid culture medium (2.0 ml) as described by Whitford et al. (1994). Samples were incubated for 3 to 7 days in a humid atmosphere at 37 C with 10% CO_2, and after 7 days, they were passaged into new liquid and solid media and incubated as described. Samples were incubated until the 14th day, and plates were observed daily using an optical 40× microscope to detect mycoplasmal colonies. When growth was observed, colonies were isolated, cloned, and identified; samples in which no growth was observed after 21 days of incubation were regarded as negative. The biochemical identification of isolated mycoplasma was based on sensitivity to digitonin, glucose fermentation, arginine and urea hydrolysis, tetrazolium reduction, film and crystal formation, phosphatase activity, casein hydrolysis, and serum liquidation (Whitford et al., 1994).

Statistical analysis was performed with the Epi Info 6.04 integrated epidemiologic statistics package (Dean et al., 1994) (Centers for Disease Control and Prevention, EE./UU.) and SPSS version 11 software (Ferrán, 1996). Differences among isolation frequency rates were evaluated relative to province, age and sex classes, and capture method as analyzed by Yates-corrected chi-squared test and Fisher's exact test. The level of significance was set at $P \leq 0.05$.

RESULTS

A total of 688 bacteria were isolated, of which 225 were gram-positive, 86 were mycoplasma, and 377 were gram-negative. Gram-positive and mycoplasmal species are shown in Table 1. *Staphylococcus aureus* and *Streptococcus* spp. were the most frequently isolated gram-positive

TABLE 1. Frequency of potential gram-positive and mycoplasmal pathogens found in 321 Spanish ibex in southern Spain.

	Conjunctiva samples		Nasal samples		Vaginal samples[a]		Spanish ibex carriers	
	No. positive	%	No. positive	%	No. positive	%	No. positive	%
Arcanobacter pyogenes	1	0.3	1	0.3	0	0	2	0.6
Bacillus spp.	45	14	12	3.7	8	8	65	20.0
Staphylococcus aureus	15	4.7	17	5.3	6	6	38	11.8
Staphylococcus xylosus	6	1.9	15	4.7	0	0	21	6.5
Staphylococcus epidermidis	8	2.5	12	3.7	2	2	22	6.8
Staphylococcus spp.	8	2.5	10	3.1	6	6	24	7.5
Streptococcus equi subsp. *zooepidemicus*	0	0	11	3.4	3	3	14	4.4
Streptococcus spp.	9	2.8	17	5.3	3	3	29	9.0
Corynebacterium spp.	8	2.5	1	0.3	1	1	10	3.1

	Conjunctiva samples		External ear canal samples		Spanish ibex carriers	
	No. positive	%	No. positive	%	No. positive	%
Mycoplasma agalactiae	6	1.9	31	9.6	46	14.3
Mycoplasma arginini	5	1.5	15	4.7	19	5.9
Mycoplasma mycoides subspp. *mycoides* LC	1	0.3	1	0.3	1	0.3
Mycoplasma sp.	5	1.5	13	4	18	5.6

[a] Sample size=100 adult Spanish ibex females.

organisms, and *Mycoplasma agalactiae* represented the most frequently isolated mycoplasma. Gram-negative bacteria identified are shown in Table 2; *Escherichia coli* was most frequently detected.

Identified bacteria species varied by source (Tables 1 and 2), but *E. coli* occurred frequently in nasal, ocular, and vaginal swabs. In nasal and ocular samples, *S. aureus* also was common. *Mannheimia haemolytica, Pasteurella multocida* biotype A (BT A), *Staphylococcus xylosus,* and *Streptococcus* spp. were frequently cultured from nasal samples, and *Branhamella ovis* and *Pseudomonas fluorescens* were frequently detected in conjunctival samples. *Mycoplasma agalactiae* was the most common species isolated from the ear canal samples, followed by *Mycoplasma arginini* (Table 1). Approximately 80% of the *M. arginini* and 70% of *M. agalactiae* cultures were isolated from external ear canal swabs.

Risk factors associated with infections with gram-positive bacteria and mycoplasma are shown in Table 3. Risk factors for gram-negative infection rates are shown in Table 4. Significant differences in infection rates were detected between males and females only for *Staphylococcus* spp. ($\chi^2=4.89$; df=1; one-tailed, $P=0.027$), *E. coli* ($\chi^2=14.07$; df=1; one-tailed, $P=0.0001$), *Serratia marcescens* ($\chi^2=4.13$; df=1; one-tailed, $P=0.042$), and *Moraxella bovis* ($\chi^2=4.55$; df=1; one-tailed, $P=0.032$).

Infection rates also were dependent on age for *M. agalactiae* ($\chi^2=16.84$; df=1; one-

TABLE 2. Frequency of potential gram-negative pathogens found in 321 Spanish ibex in southern Spain.

	Conjunctiva samples		Nasal samples		Vaginal samples[a]		Spanish ibexes carriers	
	No. positive	%	No. positive	%	No. positive	%	No. positive	%
Mannheimia haemolytica	2	0.6	34	10.6	1	1	37	11.5
Pasteurella trehalosi	8	2.5	3	0.9	0	0	11	3.4
Pasteurella multocida biotype A	7	2.2	18	5.6	1	1	26	8.1
Pasteurella multocida biotype D	0	0	0	0	0	0	0	0
Actinobacillus spp.	1	0.3	1	0.3	0	0	2	0.6
Moraxella bovis	5	1.5	2	0.6	0	0	7	2.2
Branhamella ovis	17	5.3	5	1.5	0	0	22	6.8
Acinetobacter spp.	11	3.4	5	1.5	2	2	18	5.6
Alcaligenes spp.	13	4.0	4	1.2	3	3	20	6.2
Flavobacterium spp.	6	1.9	3	0.9	0	0	9	2.8
Pseudomonas aeruginosa	1	0.3	5	1.5	1	1	7	2.9
Pseudomonas fluorescens	11	3.4	5	1.5	0	0	16	5.0
Pseudomonas cepacia	1	0.3	3	0.9	0	0	4	1.2
Pseudomonas maltophilia	3	0.9	1	0.3	1	1	5	1.5
Pseudomonas stutzeri	1	0.3	0	0	0	0	1	0.3
Other *Pseudomonas*	7	2.2	4	1.2	1	1	12	3.7
Aeromonas hydrophila	2	0.6	4	1.2	0	0	6	1.9
Vibrio spp.	7	2.2	2	0.6	0	0	9	2.8
Pleisomonas shigelloides	2	0.6	3	0.9	1	1	6	1.9
Escherichia coli	17	5.3	27	8.4	27	27	61	19.0
Salmonella arizonae	0	0	1	0.3	0	0	1	0.3
Proteus mirabilis	1	0.3	1	0.3	0	0	2	0.6
Klebsiella pneumoniae	0	0	6	1.9	0	0	6	1.9
Enterobacter agglomerans	25	7.8	32	10	7	7	64	19.9
Enterobacter cloacae	4	1.2	3	0.9	2	2	9	2.8
Enterobacter aerogenes	0	0	1	0.3	0	0	1	0.3
Serratia marcescens	0	0	3	0.9	3	3	6	1.9
Shigella spp.	1	0.3	8	2.5	0	0	9	2.8

[a] Sample size=100 adult Spanish ibex females.

tailed, $P<0.0001$), *M. arginini* ($\chi^2=12.34$; df=1; one-tailed, $P<0.001$), *Mycoplasma* spp. ($\chi^2=35.26$; df=1; one-tailed, $P=0.02$), *E. coli* ($\chi^2=25.01$; df=14; one-tailed, $P=0.032$), *M. haemolytica* ($\chi^2=31.33$; df=14; one-tailed, $P=0.005$), *P. multocida* BT A ($\chi^2=27.2$; df=14; one-tailed, $P=0.017$), *S. aureus* ($\chi^2=26.12$; df=14; one-tailed, $P=0.041$), and *Staphylococcus* spp. ($\chi^2=31.36$; df=14; one-tailed, $P=0.004$).

Mange was a risk factor for *Streptococcus equi* subsp. *zooepidemicus* ($\chi^2=4.05$; df=1; one-tailed, $P=0.04$), *M. haemolytica* ($\chi^2=9.72$; df=1; one-tailed, $P=0.001$), and *S. marcescens* ($\chi^2=5.51$; df=1; one-tailed, $P=0.01$) in Spanish ibex (Tables 3 and 4).

The geographic origin of the sampled animal also was identified as a risk factor for carrying all *Pasteurella* genera isolated: *M. haemolytica* ($\chi^2=13.19$; df=4; one-tailed, $P=0.01$), *Pasteurella trehalosi* ($\chi^2=10.38$; df=4; one-tailed, $P=0.03$), and *P. multocida* BT A ($\chi^2=25.06$; df=4; one-tailed, $P<0.001$). Regional differences in isolation rates also were detected for *B. ovis* ($\chi^2=9.54$; df=4; one-tailed, $P=0.04$) and *M. agalactiae* ($\chi^2=35.4$; df=4; one-tailed, $P<0.001$).

The disposition of the sampled animal also influenced isolation results for *M. haemolytica* ($\chi^2=3.96$; df=1; one-tailed, $P=0.04$), *P. multocida* BT A ($\chi^2=9.85$; df=1; one-tailed, $P=0.001$), *B. ovis*

TABLE 3. Risk factors associated with frequency of gram-positive and mycoplasmal pathogens carried.

	Risk factor					
	Sex		Age		Health	
	Male (n=131)	Female (n=100)	Adult (n=205)	Young (n=116)	Apparently healthy (n=271)	Mange (n=50)
Arcanobacter pyogenes	0	2	2	0	2	0
Bacillus spp.	26	22	48	19	59	8
Staphylococcus aureus	24	14	38[a]	10	38	10
Staphylococcus xylosus	12	9	21	7	24	4
Staphylococcus epidermidis	10	12	22	5	27	0
Staphylococcus spp.	7	17[a]	24[a]	4	24	4
Streptococcus equi subsp. *zooepidemicus*	17	10	17	2	9	10[a]
Streptococcus spp.	4	12[a]	15	3	15	3
Corynebacterium spp.	5	2	7	0	4	3
Mycoplasma agalactiae	23	23	17	29[a]	40	6
Mycoplasma arginini	10	9	5	14[a]	19	0
Mycoplasma mycoides subspp. *mycoides* LC	0	1	1	0	1	0
Mycoplasma sp.	9	11	8	12[a]	19	1

[a] Statistically significant difference ($P<0.05$).

($\chi^2=4.46$; df=1; one-tailed, $P=0.03$), *E. coli* ($\chi^2=9.45$; df=1; one-tailed, $P=0.002$), and *Staphylococcus* spp. ($\chi^2=10.14$; df=1; one-tailed, $P=0.002$). All of these were detected more frequently in free-ranging animals than in those that came from enclosures.

DISCUSSION

The bacterial species isolated from Spanish ibex (Tables 1 and 2) are frequently isolated in domestic small ruminant herds in this region, and these domestic herds possibly act as reservoirs for the bacterial species detected in these Spanish ibex populations. Most species of *Staphylococcus*, which are common on the skin and mucous membranes of homeotherms, are nonpathogenic and may help to prevent colonization of the skin by other potential pathogens (Queen et al., 1994). In Spanish ibex, species of *Staphylococcus*, especially *S. aureus*, were the most frequently isolated gram-positive bacteria in vaginal, nasal, and ocular samples, and a significant relationship was observed between adult females and isolation of *Staphylococcus* and *Streptococcus* spp. This probably related to the high rate of isolation from vaginal samples. Among the coagulase-positive *Staphylococcus* spp., only *S. aureus* was isolated. In Spanish ibex, this pathogen may be significant, because it often is associated with clinical mastitis of small ruminants (Deinhofer and Pernthaner, 1995). Mastitis in Spanish ibex could affect the health of newborn animals. The coagulase-negative *Staphylococcus* spp. (*S. xylosus* and *S. epidemidis*) are often found in the environment, but their role in the health of Spanish ibex remains unclear. The isolation rates for coagulase-positive *Staphylococcus* spp. were significantly lower than those for coagulase-negative *Staphylococcus* spp.; similar results have been reported for clinically healthy domestic animals (Skalka, 1991).

The potential health impact associated with the observed low prevalence of *Streptococcus* spp. in Spanish ibex is

TABLE 4. Risk factors associated with frequency of gram-negative pathogens carried.

	Risk factor					
	Sex		Age		Health	
	Male (n=131)	Female (n=100)	Adult (n=205)	Young (n=116)	Apparently healthy (n=271)	Mange (n=50)
Mannheimia haemolytica	12	16	28[a]	8	24	12[a]
Pasteurella trehalosi	7	2	9	1	10	0
Pasteurella multocida biotype A	9	10	19[a]	4	18	5
Actinobacillus spp.	3	4	7	1	7	1
Moraxella bovis	5[a]	0	5	1	5	1
Branhamella ovis	8	7	15	7	20	2
Acinetobacter spp.	4	4	8	7	10	5
Alcaligenes spp.	5	8	13	5	11	7[a]
Flavobacterium spp.	2	6	8	1	5	4[a]
Pseudomonas aeruginosa	2	2	5	2	5	2
Pseudomonas fluorescens	3	4	7	6	13	0
Pseudomonas cepacia	3	0	3	1	4	0
Pseudomonas maltophilia	1	1	2	2	4	0
Pseudomonas stutzeri	0	1	1	0	1	0
Other *Pseudomonas*	2	3	5	5	10	0
Aeromonas hydrophila	3	3	6	0	5	1
Vibrio spp.	3	3	6	3	9	0
Pleisomonas shigelloides	1	3	4	2	6	0
Escherichia coli	18	28[a]	46[a]	9	46	9
Salmonella arizonae	1	0	1	0	1	0
Proteus mirabilis	2	0	2	0	2	0
Klebsiella pneumoniae	3	3	6	0	6	0
Enterobacter agglomerans	16	15	31	18	4	9
Enterobacter cloacae	1	3	4	4	8	0
Enterobacter aerogenes	0	0	0	1	1	0
Serratia marcescens	0	5[a]	5	1	3	3[a]
Shigella spp.	4	2	6	2	7	1

[a] Statistically significant difference ($P<0.05$).

difficult to assess. In 1996, *Streptococcus* sp. were implicated in an epidemic in a French chamois (*Rupicapra rupicapra*) population (Artois et al., 1997); however, previous isolation frequencies from this species were low (1.7% [Barrat, 1991] and 4.3% [Artois, 1995]). The significant relationship between the prevalence of *S. equi* subsp. *zooepidemicus* and concurrent sarcoptic mange infections in Spanish ibex cannot be explained but deserves additional study.

Frequencies of the pyogenic bacteria *Arcanobacter pyogenes* and *Corynebacterium* spp. were low in Spanish ibex. These bacteria often are associated with abscesses, and the carrier frequency in apparently health animals generally is low. However, the potential significance of these species is unclear, because *A. pyogenes* has been associated with purulent bronchopneumonia and mortality in red deer (*Cervus elaphus*) (Rhyan et al., 1997) and with pyogenic arthritis in chamois (Lavín et al., 1998).

Mycoplasma agalactiae, which was the predominant mycoplasmal species isolated in Spanish ibex, can cause agalactia, keratoconjunctivitis, polyarthritis, and occasional abortions (Bergonier et al., 1997). High rates of infection with *M. agalactiae* occur in small domesticated ruminants from the study area (Garrido et al., 1987). Because these animals share habitat with

the Spanish ibex, considerable spillover may occur, as has been observed with *M. conjunctivae* (Belloy et al., 2003). *Mycoplasma agalactiae* most often was isolated from young animals; because of the potential for infections to result in fulminating arthritis and keratoconjunctivitis, this pathogen may represent a health risk to ibex calves.

Other species of *Mycoplasma* that can cause pleuropneumonia, mastitis, and arthritis are *M. arginini* and *Mycoplasma mycoides* subsp. *mycoides* LC. Both were isolated from Spanish ibex and have been reported in wild goats (*Capra aegagrus cretica*) (Perrin et al., 1994) and bighorn sheep (*Ovis canadensis*) (Al-Aubaidi et al., 1972; Woolf and Kradel, 1973). Infections can cause a high mortality rate in domestic ruminants, but to our knowledge, differences in prevalence among age groups or between sexes (Bar-Moshe and Rapapport, 1981; Kusiluka et al., 2000) have not been reported. *Mycoplasma conjunctivae, Mycoplasma capricolum,* or *M. mycoides* subsp. *capri* were not detected in the present study. Both *M. conjunctivae* and *M. capricolum* have been associated with outbreaks and mortality in chamois and ibex populations in the Alps (Degiorgis et al., 2000; Giacometti et al., 2002a, b), and they also have been isolated in Pyrenean chamois and mouflon (*Ovis musimon*) populations (Catusse, 1996; Terrier, 1998).

Branhamella ovis and *M. ovis* have been associated with infectious keratoconjunctivitis in roe deer (*Capreolus capreolus*) (Hatier and Artois, 1998; Hatier et al., 1999) and are possible causes of severe epidemic outbreaks (Kodjo et al., 1993). The isolation frequencies in roe deer show little differences among studies (≤20% [Gauthier, 1991] and 26% [Artois et al., 1997]) and was low in bighorn sheep (7% [Queen et al., 1994]). The frequencies for both infectious agents in the Spanish ibex are lower than those observed in roe deer or in bighorn sheep, which is consistent with the absence of reported infectious keratoconjunctivitis outbreaks in Spanish ibex populations.

Pasteurella and other related species are common in the upper respiratory tracts of animals, where they may act as opportunistic pathogens; however, *M. haemolytica* is one of the most important respiratory pathogens in domestic small ruminants (Ackermann and Brodgen, 2000) and in the bighorn sheep (Ward et al., 1997; McNeil et al., 2003; Rudolph et al., 2003; Weiser et al., 2003). *Pasteurella* spp. can be isolated from most clinically healthy bighorn sheep when samples are appropriately collected and preserved before culture (Wild and Miller, 1991). In Spanish ibex, *M. haemolytica* was the species in the *Pasteurellaceae* family isolated most frequently from nasal swabs. This may be a potentially important pathogen, and it should be considered in cases of respiratory disease in Spanish ibex.

Although *P. trehalosi* is an important pathogen of bighorn sheep (Foreyt, 1989), it does not seem to represent a significant pathogen of Spanish ibex. We are not aware of reported pasteurellosis outbreaks caused by *P. trehalosi* in Andalusia, which is consistent with our low isolation rate. In European roe deer, an isolation rate of 1.43% has been reported (Barrat, 1991), and this pathogen accounted for 2.5% of roe deer mortality (Hatier and Artois, 1999). In chamois, *P. trehalosi* is frequently (30%) isolated from nasal samples (Gauthier, 1991) and produces severe chronic lesions (Gauthier and Cadoz, 1999).

The prevalence of *P. multocida* BT A in wild and domestic small ruminants is lower than that in bovines, lagomorphs, and carnivores (Biberstein et al., 1991). It has been isolated in respiratory and ocular samples, however, and can cause mortality in wild ungulates (Catusse et al., 1996; Dunbar et al., 2000). In Spanish ibex, the low isolation rate is similar to that observed in bighorn sheep (10% [Queen et al., 1994] and 6.03% [Jaworsky et al.,

1998]), but to our knowledge, no evidence suggests mortality or population affects associated with this pathogen in Spanish ibex. However, it has been reported to be an important agent in pneumonic infection of roe deer, even with isolation frequencies as low as 1.07% (Barrat, 1991).

Escherichia coli, Shigella spp., *Salmonella* spp., and *Aeromonas hydrophila* can produce enteric processes in domestic and wild young animals with a reduction in life expectancy (Onderka and Wishart, 1988). *Escherichia coli* is an important infectious agent in wild ungulates, with high prevalence in chamois (70% [Gauthier, 1991] and 22% [Artois, 1995]) and roe deer (5% [Barrat, 1991; Artois, 1995]). In Spanish ibex, *E. coli* was isolated from 19% of tested animals.

Although we have detected numerous bacteria carried by Spanish ibex, limited information is available related to population impacts associated with these infections. Further research to understand risk factors and potential etiologies of these pathogens in Spanish ibex in Andalusia is warranted.

ACKNOWLEDGMENTS

This research was supported by Andalusian Funding and the Animal Health Department of Murcia University. We deeply appreciate the assistance of Jesús Pérez Jiménez, M[a] Carmen Pérez Alvarado, José Enrique Granados, and José J. Rodríguez during the collection and submission of samples evaluated in this study.

LITERATURE CITED

ACKERMANN, M. R., AND K. A. BRODGEN. 2000. Response of the ruminant respiratory tract to *Mannheimia haemolytica*. Microbes and Infection 2: 1079–1080.

AL-AUBAIDI, J. M., W. D. TAYLOR, G. R. BUBASH, AND A. H. DARDIRI. 1972. Identification and characterization of *Mycoplasma arginini* from bighorn sheep (*Ovis canadensis*) and goats. American Journal of Veterinary Research 33: 87–90.

ARTOIS, M. 1995. Editorial. Bulletin d'Information sur la Pathologie des Animaux Sauvages 13: 9–16.

———, C. HATIER, AND F. LAMARQUE. 1997. Bilan de l'activité du laboratoire centralisateur du reseau SAGIR en 1996. Bulletin d'Information sur la Pathologie des Animaux Sauvages 16: 9–24.

BAR-MOSHE, B., AND E. RAPAPPORT. 1981. Observations on *Mycoplasma mycoides* subsp. *mycoides* infection in Saanen goats. Israel Journal of Medical Sciences 17: 537–539.

BARRAT, J. 1991. Surveillance sanitaire de la grande faune sauvage compte rendu d'activite 1991. Bulletin d'Information sur la Pathologie des Animaux Sauvages 7: 15–28.

BELLOY, L., M. JANOVSKY, E. M. VILEI, P. PILO, M. GIACOMETTI, AND J. FREY. 2003. Molecular epidemiology of *Mycoplasma conjunctivae* in Caprinae: Transmission across species in natural outbreaks. Applied and Environmental Microbiology 69: 1913–1919.

BERGONIER, D., X. BERTHELOT, AND F. POUMARAT. 1997. Contagious agalactia of small ruminants: Current knowledge concerning epidemiology, diagnosis and control. Revue Scientifique et Technique. Office International des Épizooties 16: 848–873.

BIBERSTEIN, E. L., S. J. SPENCER, P. H. KAAS, AND D. C. HIRSH. 1991. Distribution of indole-producing urease-negative pasteurellas in animals. Journal of Veterinary Diagnostic Investigation 3: 319–323.

CATUSSE, M., R. CORTI, J. M. CUGNASSE, D. DUBRAY, P. GIBERT, AND J. MICHALLET. 1996. La grande faune sauvage de montagne, Hatier Littérature Générale, Paris, France, 260 pp.

DEAN, A. G., J. A. DEAN, D. COLOUMBIER, K. A. BRENDEL, D. C. SMITH, A. H. BURTUM, R. C. DICKER, K. SULLIVAN, R. F. FAGAN, AND T. G. ARNER. 1994. EpiInfo, version 6: A word processing, database, and statistic program for epidemiology on microcomputers. Center for Disease Control and Prevention, Atlanta, Georgia.

DEGIORGIS, M. P., J. FREY, J. NICOLET, E. M. ABDO, R. FATZER, Y. SCHALATTER, S. REIST, M. JANOVSKY, AND M. GIACOMETTI. 2000. An outbreak of infectious keratoconjunctivitis in Alpine chamois (*Rupicapra rupicapra*) in Simmental-Gruyères, Switzerland. Schweizer Archiv fur Tierheilkunde 142: 520–527.

DEINHOFER, M., AND A. PERNTHANER. 1995. *Staphylococcus* spp. as mastitis-related pathogens in goat milk. Veterinary Microbiology 43: 161–166.

DUNBAR, M. R., M. J. WOLCOTT, R. B. RIMLER, AND B. M. BERLOWSKY. 2000. Septicemic pasteurellosis in free-ranging neonatal pronghorn in Oregon. Journal of Wildlife Diseases 36: 383–388.

FANDOS, P. 1991. La cabra montés (*Capra pyrenaica*) en el Parque Natural de las Sierras de Cazorla, Segura y Las Villas. Instituto Nacional para la conservación de la naturaleza/Consejo Superior de Investigaciones Agrarias (eds.). Madrid, España, 215 pp.

FERRÁN, M. 1996. SPSS para Windows, programa-

ción y análisis estadístico. McGraw-Hill Interamericana de España, Madrid, España, 580 pp.

FOREYT, W. 1989. Fatal *Pasteurella haemolytica* in bighorn sheep after direct contact with clinically normal domestic sheep. American Journal of Veterinary Research 50: 341–344.

GARRIDO, F., L. LEÓN, J. L. LADERO, L. CUELLAR, AND M. A. DIAZ. 1987. Contagious Agalactia in Spain. *In* Contagious agalactia and other mycoplasmal diseases of small ruminants, M. Lambert and G. E. Jones (eds.). Commission of the European Community, Luxembourg, pp. 1–6.

GAUTHIER, D. 1991. Pathologie respiratoire et ecologie microbienne des chamois des massifs del Bauges et de la Vanoise. Bulletin d'Information sur la Pathologie des Animaux Sauvages 7: 7–96.

———, AND M. CADOZ. 1999. Bilan des connaissances sur les pathologies respiratoires des chamois. Bulletin d'Information sur la Pathologie des Animaux Sauvages 21: 17–26.

GIACOMETTI, M., M. JANOVSKY, L. BELLOW, AND J. FREY. 2002a. Infectious keratoconjunctivitis of ibex, chamois, and other Caprinae. Revue Scientifique et Techique Office International des Epizooties 21: 335–345.

———, ———, J. JENNY, J. NICOLET, L. BELLOY, E. GOLDSCHMIDT-CLERMONT, AND J. FREY. 2002b. *Mycoplasma conjunctivae* infection is not maintained in Alpine chamois in Eastern Switzerland. Journal of Wildlife Diseases 38: 297–394.

HATTIER, C., AND M. ARTOIS. 1999. Bilan de l'activité du laboratoire centralisateur du reseau SAGIR au premier semestre 1999. Bulletin d'Information sur La Pathologie Des Animaux Sauvages 21: 7–14.

———, ———, AND F. LAMARQUE. 1998. Bilan de l'activité du laboratoire centralisateur du reseau SAGIR en 1998. Bulletin d'Information sur la Pathologie des Animaux Sauvages 20: 7–30.

JAWORSKY, M. D., D. L. HUNTER, AND A. C. S. WARD. 1998. Biovariants of isolates of *Pasteurella* from domestic and wild ruminants. Journal of Veterinary Diagnostic Investigation 10: 9–55.

KODJO, A., A. MOUSSA, E. BORGES, AND Y. RICHARD. 1993. Identification of *Moraxella*-like bacteria isolated from caprine and ovine nasal flora. Journal of Veterinary Medicine Series B 40: 97–104.

KRIEG, N. R., AND J. G. HOLT. 1984. Bergey's manual of systematic bacteriology, Vol. 1. Williams and Wilkins, London, UK, 964 pp.

KUSILUKA, L. M. J., W. D. SEMUGURUKA, R. R. KAZWALA, B. OJENIYI, AND N. F. FRIIS. 2000. Demonstration of *Mycoplasma capricolum* subsp. *capripneumoniae* and *Mycoplasma mycoides* subsp. *mycoides*, small colony type, in outbreaks of caprine pleuropneumonia in eastern Tanzania. Acta Veterinaria Scandinavica 41: 311–319.

LAUÍN, S., I. MARCO, J. FRANCH, AND L. ABARCA. 1998. Report of a case of pyogenic arthritis associated with *Actinomyces pyogenes* in chamois (*Rupicapra pyrenaica*). Zentralblatt Fur Veterinarmedizin. Reihe B 45: 251–253.

LEÓN VIZCAÍNO, L., M. R.RUÍZ DE YBAÑEZ., M. J. CUBERO, J. M. ORTÍZ, J. ESPINOSA, L. PÉREZ, M. A. SIMÓN, AND F. ALONSO. 1999. Sarcoptic mange in Spanish ibex from Spain. Journal of Wildlife Diseases 35: 647–659.

MCNEIL, H. J., P. E. SHEWEN, R. Y. LO, J. A. CONLON, AND M. W. MILLER. 2003. Novel protease produced by *Pasteurella threalosi* serotype 10 isolate from a pneumonic bighorn sheep: Characteristics and potential relevance to protection. Veterinary Microbiology 93: 145–152.

ONDERKA, D. K., AND W. D. WISHART. 1988. Experimental contact of *Pasteurella haemolytica* from clinically normal domestic sheep causing pneumonia in Rocky Mountain bighorn sheep. Journal of Wildlife Diseases 24: 663–667.

PALOMARES, F., AND I. RUIZ-MARTÍNEZ. 1993. Status und Aussichten für den Schutzpopulation des spanischen Steinbocks (*Capra pyrenaica*) im Sierra Mágina NaturPark in Spanien. Journal of Jadwissen 39: 87–94.

PÉREZ, J. M., I. RUIZ-MARTÍNEZ, J. E. GRANADOS, R. C. SORIGUER, AND P. FANDOS. 1997. The dynamics of sarcoptic mange in the ibex population of Sierra Nevada in Spain—Influence of climatic factors. Journal of Wildlife Research 2: 86–89.

———, J. E. GRANADOS, R. C. SORIGUER, P. FANDOS, F. J. MARQUEZ, AND J. P. CRAMPE. 2002. Distribution, status, and conservation of the Spanish ibex, *Capra pyrenaica* (Mamalia: Artiodactyla). Mammal Review 32: 26–39.

PERRIN, J., M. MÜLLER, N. ZANGGER, AND J. NICOLET. 1994. Infection à *Mycoplasma mycoides* spp. m*ycoides* LC (large colony type) chez des cabris bézoard (*Capra aegagrus cretica*) au jardin zoologique de Berne (Suisse). Schweizer Archiv fur Tierheilkunde 136: 270–274.

QUEEN, C., A. C. S. WARD, AND D. L. HUNTER. 1994. Bacteria isolated from nasal and tonsillar samples of clinically healthy Rocky Mountain bighorn and domestic sheep. Journal of Wildlife Diseases 30: 1–7.

RHYAN, J. C., K. AUNE, D. R. EWALT, J. MARQUARDT, J. W. MERTINS, J. B. PAYEUR, D. A. SAARI, P. SCHLADWEILER, E. J. SHEEHAN, AND D. WORLEY. 1997. Survey of free-ranging elk from Wyoming and Montana for selected pathogens. Journal of Wildlife Diseases 33: 290–298.

RUDOLPH, K. M., D. L. HUNTER, W. J. FOREYT, E. F. CASSIRER, R. B. RIMLER, AND A. C. WARD. 2003. Sharing of *Pasteurella* spp. between free-ranging bighorn sheep and feral goats. Journal of Wildlife Diseases 39: 897–903.

SKALKA, B. 1991. Occurrence of staphylococcal

species in clinically healthy domestic animals. Veterinarni Medicina (Praha) 36: 9–19.

SNEATH, P. H. A., N. S. MAIR, M. E. SHARPE, AND J. G. HOLT. 1984. Bergey's manual of systematic bacteriology, Vol. 2. Williams & Wilkins, London, UK, 634 pp.

TERRIER, M. E. 1998. La kératoconjonctivite des ongulés sauvages de montagne. Reproduction experimentale chez le mouflon (*Ovis gmelini musimon*). PhD Thesis, Claude Bernard University, Lyon, France, 144 pp.

WARD, A. C. S., D. L. HUNTER, M. D. JAWORSKY, P. J. BENOLKIN, M. P. DOBEL, J. B. JEFFRESS, AND G. A. TANNER. 1997. *Pasteurella* spp. in sympatric bighorn and domestic sheep. Journal of Wildlife Diseases 33: 544–557.

WEISER, G. C., W. J. DE LONG, J. L. PAZ, B. SHAFII, W. J. PRICE, AND A. C. WARD. 2003. Characterization of *Pasteurella multocida* associated with pneumonia in bighorn sheep. Journal of Wildlife Diseases 39: 536–544.

WHITFORD, H. W., R. F. ROSENBUSCH, and L. H. LAUERMAN (eds.). 1994. Mycoplasmosis in animals: Laboratory diagnosis. Iowa State University Press, Iowa, 166 pp.

WILD, M. A., AND M. W. MILLER. 1991. Detecting nonhemolytic *Pasteurella haemolytica* infections in healthy Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*): Influences of sample site and handling. Journal of Wildlife Diseases 27: 53–60.

WOOLF, A., AND D. C. KRADEL. 1973. Mortality in captive bighorn sheep—Clinical, hematological, and pathological observations. Journal of Wildlife Disease 9: 12–17.

Received for publication 31 May 2004.