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Authors: León-Vizcaíno, Luis, José Cubero, María, González-Capitel, Emilio, Simón, Miguel Angel, Pérez, Linarejos, et al.

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EXPERIMENTAL IVERMECTIN TREATMENT OF SARCOPTIC MANGE AND ESTABLISHMENT OF A MANGE-FREE POPULATION OF SPANISH IBEX

Luis León-Vizcaíno,[1] María José Cubero,[1] Emilio González-Capitel,[3] Miguel Angel Simón,[3] Linarejos Pérez,[3] M. Rocío Ruiz de Ybáñez,[2] Juana M. Ortíz,[2] Mónica González Candela,[1] and Francisco Alonso[2]

[1] Unidad de Enfermedades Infecciosas, Departamento de Patología Animal, Facultad de Veterinaria, Universidad de Murcia, Spain
[2] Unidad de Parasitología y Enfermedades Parasitarias, Departamento de Patología Animal, Facultad de Veterinaria, Universidad de Murcia, Spain
[3] Parque Natural de las Sierras de Cazorla, Segura y Las Villas. Consejería del Medio Ambiente de Andalucía, Cazorla, Jaén, Spain
[4] Corresponding author (e-mail: lleonvi@um.es)

ABSTRACT: Ivermectin was used to treat sarcoptic mange in Spanish ibex (*Capra pyrenaica hispanica*). Its therapeutic effectiveness was analyzed when it was administered through subcutaneous injection, to sick animals in the consolidation stage of mange (third phase) and, with double injections to chronically affected animals (fourth phase) at a dosage of 0.2 or 0.4 mg/kg body weight (bw). Three wk after treatment, the animals in the third phase of mange treated with a high dose (0.4 mg/kg bw) of ivermectin were completely cured. The same result was achieved after 4 wk of treatment in those animals in phase 3 of mange when 0.2 mg/kg body weight was used. Double injection with ivermectin, even at high doses, did not guarantee the complete cure of all cases of sarcoptic mange in the chronic stage (phase 4); only three of six animals were free of *Sarcoptes scabiei.* The second experiment consisted on the application of a sanitation program in order to obtain a population of Spanish ibex free from *S. scabiei,* starting with free-ranging animals, some of them healthy and others sick. After capture the animals were classified as chronically ill, in which case they were excluded from the program, mite carriers and healthy specimens. All the animals were treated first topically with foxim (500 mg/l) and subcutaneously with ivermectin (0.4 mg/kg bw). The infected animals were housed in the treatment pen, and received two doses of ivermectin (0.2 mg/kg bw) at an interval of 15 days, then spent 15 days in the quarantine pen, where they received a further dose before they were included in the pool of healthy animals, and immediately were placed in the quarantine phase. The sanitation we implemented was fully effective in curing the affliction of Spanish ibex affected by *S. scabiei.*

Key words: *Capra pyrenaica hispanica*, ivermectin, mange, sanitation program, *Sarcoptes scabiei,* scabies, Spanish ibex, therapeutic.

INTRODUCTION

The Spanish ibex (*Capra pyrenaica*) is a wild artiodactyl that currently lives in several mountain zones of Spain. In 1988 the largest population of the species was present in the "Sierras de Cazorla, Segura y Las Villas Natural Park" (Cazorla NP) (Jaén, España) (Fandos, 1991). At the end of 1987 the first reported outbreak of sarcoptic mange occurred in the Spanish ibex at Cazorla NP (León-Vizcaíno et al., 1989, 1992, 1999). The high mortality associated with this epizootic drastically reduced the numbers of Spanish ibex (León-Vizcaíno et al., 1992). In order to bring the epizootic under control and to preserve the native Spanish ibex of the Cazorla NP an intervention program was designed.

Although the Spanish ibex population was spread throughout the mountains of the Cazorla N. P. (214.000 ha; VH9070, WH5070, VG9070, WG5070), most of these animals were concentrated in the "Coto Nacional" reserve. The option of using an oral administration of ivermectin to control the epizootic was abandoned in favor of distance subcutaneous or superficial intramuscular injection by means of rifle darts because (1) the Coto Nacional reserve is a large area (approximately 84.000 ha) which offers an abundance of food both in meadows and in forests; (2) the difficulty of access to some parts presents

considerable problems for the distribution of treated food; and (3) at the time the oral use of ivermectin was not authorized in Spain. The two objectives of the program were: (1) to evaluate the efficacy of directly or remotely injected ivermectin in Spanish ibex severely affected by sarcoptic mange; and (2) to establish a separate Spanish ibex community free of *Sarcoptes scabiei* which would function as a genetic pool in order to reintroduce the species later.

MATERIALS AND METHODS

Collection of Spanish ibex

The locality of the national park and the other sites are described, including map coordinator in León-Vizcaíno et al. (1999). To capture both those animals intended for the treatment and those needed to establish a reservoir of Spanish ibex free of *Sarcoptes scabiei,* four pens were constructed using a thick fence made with plant ropes and a curtain door operated manually from a distance (Alados and Escos, 1990). The animals were attracted to the pens with salt and alfalfa. For better transportation to the Nava de San Pedro Park within the Cazorla NP, and also in order to reduce stress levels for the animals caused by handling during clinical examination, the captured animals were sedated with a combination of 0.1 mg/kg body weight (bw) of ketamine (Imalgene®, Rhône Mérieux, Lyon, France) and 0.2 mg/kg bw of xylacine (Rompum®, Bayer, Leverkunsen, Germany) delivered by intramuscular injection prior to collecting skin scrapings or applying topical Foxim (Sarnacuran®, Bayer) anti-mange treatment (500 mg/l of water). Once safely housed, animals were revived with yohimbine (0.2 mg/kg b. w.). For the sanitation program the animals were captured at monthly intervals until the population density of animals in the wild had reached such a low level due to the dramatic mortality rate caused by the mange, that any attempt to make fresh captures was pointless.

The Nava de San Pedro Park was equipped with a complex set of pens, some of which were adapted in order to carry out both the treatment with ivermectin and, some months later, the anti-mange sanitation program. Inside the main one, which covered some 400 ha., there had been an established group of 57 Spanish ibex. This pen, with its original population, was used as a reserve for the species with a view to future releases into the wild.

Parasitology

Each animal captured was carefully examined to determine the presence of mites as previously described (León-Vizcaíno et al., 1999). Briefly, three 4 cm^2 skin scrapings from 18 external regions on both sides of the body were put into tubes, treated with 10% KOH solution and incubated at 37 C for 8 hr. Once centrifuged at 800 g for 5 min, the supernatant was discarded and the sediment was carefully mixed with saturated glucose solution. Finally, after 10 min the upper layer was collected and examined under a stereoscopic microscope to determine the presence of mites. Specific identification of the parasite was performed following the description given by Pence (1984).

In those animals suffering sarcoptic mange which underwent therapeutic research, the level of cutaneous infestation by *S. scabiei* was subsequently measured prior to beginning the treatment, 14 days after, and weekly for 2 mo. Mites were counted in 4 cm^2 skin scrapings from three of the external affected areas, preferably neck, shoulder, and chest. In each of the subsequent examinations the samples were always taken from the same external regions of the body. The mites found were counted following the method described by Meleney et al. (1980). After every skin scrape, the area was treated with scarring agents, antibiotics and disinfectants. The skin samples were treated as described above with the modification as described by Kinzer (1983); they were immersed in detergent solution and shaken vigorously under the heat generated by a light bulb of approximately 100W until the scabs disintegrated. The supernatant of the sample suspension in glucose-saturated solution was placed on a Petri plate which was then heated in the same way for 5 min in order to separate mobile and immobile mites. The pipette used to transfer the supernatant also was heated and analyzed under a microscope to include any mites which might have remained attached to it. The average of infestation per cm^2 of affected skin was calculated from the three partial counts.

Use, efficacy, and toxicity of ivermectin in the Spanish ibex

The experimental treatment was conducted from September to December 1988, in female Spanish ibex, more than 2-yr-old and suffering from sarcoptic mange in the third and fourth phases. The treatment used ivermectin (Ivomec® 1% injection for cattle, Merck, Sharp and Dohme, Inc., Rahway, New Jersey, USA) in its parenteral form. The final test consisted of distance injection of the drug by means of a dart with a needle with no gaff (Speedy, Dist-Inject;

Peter Catt AG, Basal, Switzerland) shot from a rifle. Darts were selected to use needles as short as possible, so the route of administration would be subcutaneous or superficial intramuscular. The treatment groups consisted of 15 animals that were divided into five groups, each of which was isolated in one of five special pens. To characterize the disease we followed the four pathochronic stages identified by Jackson et al. (1983) and Sheikh-Omar et al. (1984) for mange in domestic goats; Phase 1 or sensitization period (the skin apparently normal, but *S. scabiei* can be observed when the skin is scraped); phase 2 or hypersensitive period (inflamed skin, pruritus especially on the face and the bony protuberances); phase 3 or consolidation period (clinical signs characterized by intense pruritus, alopecia, hyperkeratosis and self-excoriation limited to few areas of the body); and phase 4 or chronic period (severe and advanced cases, emaciation, skin sparsely covered in hair, numerous scabs, and deep dermal fissures extending to many external areas of the body).

The therapeutic details were different for each group and included: Group 1 treatment of sarcoptic mange in the third phase with a single dose of ivermectin (0.4 mg/kg bw) administered by syringe; Group 2 treatment of sarcoptic mange in third phase with a single dose of ivermectin (0.4 mg/kg bw) administered by rifle dart; Group 3 treatment of sarcoptic mange in third phase with a single dose of ivermectin (0.2 mg/kg bw) administered by syringe; Group 4 treatment of sarcoptic mange in fourth phase with two doses of ivermectin (0.2 mg/kg bw) administered by syringe at an interval of 2 wk; and Group 5 treatment of sarcoptic mange in fourth phase with two doses of ivermectin (0.4 mg/kg bw) administered by syringe at an interval of 2 wk.

The three groups (1, 2, 3) of animals in the third phase of the disease and the two groups (4, 5) in the fourth phase consisted of homogeneous individuals according to the average number of mites, both total and mobile, per cm^2 of affected skin. Starting in the second week after the beginning of the experiment, clinical and parasitological observations were continued for 2 mo in order to follow the recovery of general health, the disappearance of pruritus, and the healing of skin lesions. In addition, the disappearance of mites on the skin and the proportion of mobile mites also were recorded.

Sanitation program

A sanitation plan for the establishment of an isolated population of Spanish ibex free of *S. scabiei,* was designed and performed from February to May 1989. The ibex captured within the park itself, included both those clinically affected by *S. scabiei* and apparently healthy animals. The infrastructure for this sanitary program involved the employment of five metal mesh pens, which were already available in Nava de San Pedro Park. Each of two "cure pens," destined for treatment of sick animals, was connected to a "quarantine pen." These last enclosures were designed both for the transfer of Spanish ibex before the treatment program and for first-boarding those ones categorized as *S. scabiei* free. The quarantine pens were linked to a general reserve pen where the reservoir population was to be established. In order to avoid any possible cross-infection through physical contact, both the perimeter fence, and the fences separating pens were made up of two separate lines of netting. The walls and tree-trunks in both therapeutic and quarantine precinct were disinfected weekly using a lindane solution (Parasitiven®, Iven, Spain).

The handling of the animals inside each pen was always done in groups, following the all in/all out method. All the animals were given feed supplemented by a compound of vitamins and minerals (granulated Baymix®, Bayer, Leverkunsen, Germany) to support the clinical treatment. The sanitation program experiment was supported by clinical followup (disappearance of pruritus, hair growth, recovery of normal appearance of the skin) using a telescope.

Those animals in the fourth phase were put out on the capture site, since our experience in treating those animals had not made it clear whether the treatment was safe and gave a quick parasitological result. In any case, they were given a subcutaneous dose of 0.4 mg/kg bw of ivermectin. The other Spanish ibex, including those that were apparently healthy, on arrival at the Nava de San Pedro Park and while still under the effects of the anaesthetic, were successively examined. This was to diagnose whether or not they were infected by *S. scabiei,* and, if so, to determine the stage of the disease according to extent and intensity of the lesions. They also were given an initial treatment using a high dosage of ivermectin (0.4 mg/kg bw), and a foxim spray (500 mg/l). Despite the fact that in our therapeutic assay it had been shown that a single dose of 0.2 mg ivermectin/kg bw was effective in the parasitological treatment of non-chronic phases, we opted for a double dose in order to achieve quicker results (2 wk *vs.* 3 wk).

After the first anti-mange treatment, those animals presenting no apparent mange lesions were housed in boxes for the parasitological di-

agnosis. The microscopic analysis was performed on dermal scrapings from 18 external regions on both sides of the body (face, retroarticular region, neck, shoulder, costal area, elbow, carpus, chest, axilla, back, flank, lumbarsacral region, coxal tuber region, knee, tarsus, abdomen, groin and scrotum). The Spanish ibex confirmed as free of *S. scabiei* ($n = 17$) were placed in quarantine pens. On the other hand, the infected animals ($n = 32$), with or without apparent scabies lesions, were enclosed in a treatment paddock. Two weeks later they received a second dose of ivermectin (0.2 mg/kg bw) by distance injection, and 2 wk after, if both pruritus and skin injuries had completely disappeared, they were given another dose (0.2 mg/kg bw) of ivermectin and taken into the quarantine precinct exactly like the healthy animals. For a 2 wk quarantine period the animals were clinically monitored and, if there were no clinical symptoms of mange, they were given one dose of ivermectin and taken to a reserve enclosure.

Before the sanitation program began, the 12 animals which had been cured parasitologically after the treatment were incorporated into the reservoir of healthy specimens.

Statistical analyses

The mean number of *S. scabiei* per cm^2 of skin was used as a variable in order to determine homogeneity, both in the three trial groups in the third phase of the mange and in the two groups of the fourth phase. Statistical comparisons among and within groups of the different weekly mite counts (total and mobile) were performed using the single-factor ANOVA test. Only differences with $P < 0.05$ were considered statistically significant. All analyses were carried out using the EpiInfo 6 integrated epidemiological statistics package (Dean et al., 1994) and SPSS software (Ferrán, 1996).

RESULTS

Use, efficacy, and toxicity of ivermectin in the Spanish ibex

The comparison made at the start of the treatment experiment (week 0) of the average *S. scabiei* counts across groups 1, 2 and 3 and across groups 4 and 5 showed that there were no statistically significant differences. Therefore, the groups can be considered to be relatively homogeneous. It was clear that in natural conditions (at the moment of capture) those Spanish ibex in the third phase had a significantly higher number of parasites on the skin (mean number of mites per cm^2) than those in the fourth phase. This was both in terms of the total number of *S. scabiei* (17.1 versus 11.8, $t = 3.546$, df = 5, $P = 0.016$) and of the mobile mites (15.0 versus 9.9, $t = 4.092$, df = 5, $P = 0.009$).

Trial data used for registration of label efficacy claims are summarized in Tables 1, 2, and 3. These data consisted of chronological counts of total and mobile mites found in the three 4 cm^2 scrapings in each animal (Table 1), summary data (mean and standard deviation) of these counts in each experimental group (Table 2), and the clinical evolution of the animals during the period of the treatment (Table 3).

All sick Spanish ibex in third phase (Groups 1, 2, 3) were cured following ivermectin treatment, whether the dose was of 0.2 or 0.4 mg/kg bw, and whether the injection was manual or by means of a rifle dart. No apparent deleterious effects were associated with either the dosages or the procedures (manual or by an impact activated dart shot) for injection of ivermectin. The numbers of mites decreased steadily during the weeks of the experiment. Using 0.4 mg ivermectin/kg bw no mites were found in any of the six animals in Groups 1 and 2 at 21 days after the drug was administered. In the second week, the average of skin parasites was significantly lower, almost disappearing at 0.5 and 0.75 mobile mites/cm^2, respectively. After 14 days, the reduction in the average total number of mites (mobile and immobile) in Group 1 was 82% ($P = 0.023$, $t = 6.431$, 2 df) while the reduction in the number of mobile mites was 96% ($P = 0.020$, $t = 7.008$). Group 2 was not significantly different from Group 1 with a reduction of 83% ($P = 0.033$, $t = 5.370$) in total mites, and 96% ($P = 0.039$, $t = 4.907$) in mobile mites.

Ivermectin injected subcutaneously or intramuscularly, both directly by syringe (Group 1) and by impact dart (Group 2), at a dosage of 0.4 mg/kg bw, was highly effective in curing mange in the third stage. There were still some scabs 14 days

TABLE 1. *Sarcoptes scabiei* numbers in three 4 cm^2 skin scrapings examined before ivermectin treatment and weekly thereafter for 1 mo. Counts consist of total and mobile mites in each animal of each experimental group.

Group	Animal	Clinical stage of mange	Dose of ivermectin mg/kg bw[a]	Means of application and reiteration	Weeks after initial treatment (total mites/mobile mites)							
					0	2	3	4	5	6	7	8
1[b]	1	Phase 3	0.4	S[c]	225/204	61/13	0/0	0/0	0/0	0/0	0/0	0/0
	2				130/119	19/0	0/0	0/0	0/0	0/0	0/0	0/0
	3				239/196	47/6	0/0	0/0	0/0	0/0	0/0	0/0
2[d]	4	Phase 3	0.4	R[e]	158/131	7/0	0/0	0/0	0/0	0/0	0/0	0/0
	5				252/219	54/17	0/0	0/0	0/0	0/0	0/0	0/0
	6				216/191	42/9	0/0	0/0	0/0	0/0	0/0	0/0
3[f]	7	Phase 3	0.2	S[g]	203/182	44/31	11/3	1/0	0/0	0/0	0/0	0/0
	8				176/156	61/15	7/1	0/0	0/0	0/0	0/0	0/0
	9				246/224	48/26	9/6	4/0	0/0	0/0	0/0	0/0
4[h]	10	Phase 4	0.2	SS[i]	175/131	93/58	33/19	24/14	27/21	69/45	57/46	†[j]
	11				139/116	65/46	20/8	10/4	2/2	13/8	0/0	0/0
	12				154/133	85/69	46/24	28/12	6/4	18/11	30/21	26/20
5[k]	13	Phase 4	0.4	SS[l]	116/101	39/26	11/10	6/3	1/0	0/0	0/0	0/0
	14				148/126	74/54	36/21	18/15	21/19	43/32	87/62	†
	15				123/107	58/15	19/11	10/3	3/2	0/0	0/0	0/0

[a] Kg bw = Kilogram of body weight.
[b] Group 1–Mange in pathogenic phase 3.
[c] One dose of 0.4 mg ivermectin/kg bw administered by syringe.
[d] Group 2–Mange in pathogenic phase 3.
[e] One dose of 0.4 mg ivermectin/kg bw administered by rifle.
[f] Group 3–Mange in pathogenic phase 3.
[g] One dose of 0.2 ivermectin/kg bw administered by syringe.
[h] Group 4–Mange in pathogenic phase 4.
[i] Double dose of 0.2 mg ivermectin/kg bw administered by syringe with 7 interval days.
[j] † = Death.
[k] Group 5–Mange in pathogenic phase 4.
[l] Double dose of 0.4 mg ivermectin/kg bw administered by syringe with 7 interval days.

after treatment in four of the six animals concerned, but after 21 days these had disappeared. The animals' behavior during the second week was almost normal, although there was still moderately intense pruritus in one animal, occasional bouts of pruritus in another, while the third no longer scratched. The itching disappeared completely in the third week. The recovery of hair growth also was apparent in the second week. The skin lesions showed complete clinical recovery 4 wk after treatment.

All animals from Group 3 (ivermectin 0.2 mg/kg bw) also showed marked improvements, but 1 wk later than Groups 1 and 2; normal behavior with occasional pruritus was observed the third week after treatment, and complete absence of the scabs occurred 1 wk later. The skin recovered to a normal appearance 5 wk posttreatment. In the second week after the trial began, the reduction in the number of parasites (84% and 96% of total and mobile mites respectively) showed no significant differences from the reductions with double doses. However, the mites did not disappear until 5 wk after treatment.

The action of ivermectin was similar, with no significant differences ($P \leq 0.05$) during the 2 mo study period, between the 0.2 mg dose (Group 4) and the 0.4 mg dose (Group 5), although the reduction in the number of parasites (mites per cm^2 of skin) was always greater with the higher dose of drug. The disappearance of *S. scabiei* was not marked until the second week after treatment, both in Group 4 ($t = 19.810$; df = 2; $P = 0.003$) and in Group 5 ($t = 19.969$; df = 2; $P = 0.003$), and the

TABLE 2. Total and mobile *sarcoptes scabiei* numbers (mean ± standard deviation) in three 4 cm^2 skin scrapings examined before ivermectin treatment and weekly thereafter for 2 mo, in each of five experimental groups.

Group[a]	Clinical stage of mange	Dose of ivermectin mg/kg bw	Means of application and reiteration[b]	Total and mobile mites	Weeks after initial treatment							
					0	2	3	4	5	6	7	8
1	Phase 3	0.4	S	T[c]	198.00 ± 59.30	43.33 ± 6.39						
				M[d]	173.0 ± 46.94	21.39 ± 6.51						
2	Phase 3	0.4	R	T	208.67 ± 47.43	34.33 ± 24.42						
				M	180.33 ± 44.96	8.66 ± 8.50						
3	Phase 3	0.2	S	T	208.33 ± 35.30	51.00 ± 8.88	9.00 ± 2.00	1.66 ± 2.08				
				M	187.33 ± 34.31	24.00 ± 8.18	3.33 ± 2.51					
4	Phase 4	0.2	SS	T	156.00 ± 18.08	81.00 ± 14.42	33.00 ± 13.00	20.66 ± 9.45	11.66 ± 13.42	33.33 ± 30.98	29.00 ± 28.51	
				M	126.67 ± 9.29	57.67 ± 11.50	17.00 ± 8.18	10.00 ± 5.29	9.00 ± 10.44	21.33 ± 20.55	22.33 ± 23.02	
5	Phase 4	0.4	SS	T	129.00 ± 16.82	57.00 ± 17.52	22.00 ± 12.77	11.33 ± 6.11	8.33 ± 11.01	14.33 ± 24.82		
				M	111.33 ± 13.05	31.67 ± 20.11	14.00 ± 6.08	7.00 ± 6.93	7.00 ± 10.44	10.67 ± 18.47		

[a] See Table 1 for group explanation.
[b] See Table 1 for explanation.
[c] Total of mites.
[d] Mobile mites.

TABLE 3. Cutaneous signs related to clinical evolution of mange in Spanish ibex naturally infected by *Sarcoptes scabiei* and treated with ivermectin.

Group[a]	Animal	Stage of mange	Dose of ivermectin (mg/kg bw)[b]	Means of application	Weeks after initial treatment							
					0	2	3	4	5	6	7	8
1	1	Phase 3	0.4	Syringe	P[c] S[d]	Pw[e] Ss[b] H[g]	C					
	2				P S	H	C					
	3				P S	Po[i] Ss H	C					
2	4	Phase 3	0.4	Riffle	P S	H	C					
	5				P S	Pw Ss H	C					
	6				P S	Po Ss H	C					
3	7	Phase 3	0.2	Syringe	P S	Pw Ss H	Po Ss	C				
	8				P S	Pw Ss H	Po Ss	C				
	9				P S	Pw Ss H	Po Ss	C				
4	10	Phase 4	0.2 (double)	Syringe	P S	P S	P S	Pw S	Pw S	P S	P S	†[j]
	11				P S	P S	Pw Ss	Pw Ss	Pw Ss	Po Ss H	Po Ss H	C
	12				P S	P S	P S	P S	Pw Ss	Pw Ss	Pw Ss	Po Ss H
5	13	Phase 4	0.4 (double)	Syringe	P S	P S	Pw Ss H	Pw Ss H	Pw Ss H	Po Ss H	C	
	14				P S	P S	P S	P S	Pw S	Pw S	P S	†
	15				P S	P S	P S	Pw Ss H	Pw Ss H	Po Ss H	C	

[a] See Table 1 for explanation.
[b] See Table 1 for explanation.
[c] Pruritus intense.
[d] Scab.
[e] Pruritus weak.
[f] Scab scanty.
[g] Hair growth start.
[h] Cure.
[i] Pruritus occasional.
[j] † = Death.

third week (Group 4 $t = 7.686$; df = 2; $P = 0.017$. Group 5 $t = 9.966$; df = 2; $P = 0.010$).

Individually, the Spanish ibex in the fourth phase followed different patterns of development in any of the treatment groups. The treatments were not fully effective in curing these severe, advanced cases of sarcoptic mange, since one animal from each group died during the eighth week after treatment. In these two cases, the number of mites on the skin showed minimum values (2.0 and 1.1 versus 1.5 and 1.2 total and mobile mites average/cm^2 respectively) 1 wk after the injection of the second dose of ivermectin, and then rose to medium levels (4.7 and 3.8 versus 7.2 and 5.1), but the skin lesions remained widely extended over the whole body, and their seriousness hardly diminished. Furthermore, individual one in Group 4 continued to be a carrier of mobile mites, although at a low level (1.2/cm^2), at the end of the observation period (2 mo), and there were still moderate lesions and itching. On the other hand, in three of the six animals the therapy was effective, and no mobile mites were observed in the third and fourth weeks after reinjection of 0.4 mg ivermectin/kg bw and 5 wk after 0.2 mg ivermectin/kg bw reinjection. In these individuals, the clinical recovery (lack of itching, hair growth, and few scars) occurred earlier in the animals treated with a dose of 0.4 mg ivermectin/kg bw than in the animal which received the lower dose.

Sanitation program

Sixty-three Spanish ibex were captured during 1989. Seventeen were free of mites and 46 were infected with *S. scabiei.* The affected Spanish ibex were classified in one of the four pathogenic stages of mange: phase 1 ($n = 3$), phase 2 ($n = 12$), phase 3 ($n = 17$), or phase 4 ($n = 14$). These last 14 ibex were excluded from the antimange sanitation program. At the end of the therapeutic period, the 32 Spanish ibex affected by nongeneralized mange seemed to be healthy, and showed no signs of mange during the subsequent quarantine period.

In the pen reserved for a pool of healthy animals, there were already 36 Spanish ibex free of *S. scabiei,* which were used in this study as control population in terms of being mite free, both for the treatment and for the sanitation program. Twelve animals were added from the treatment, and 49 from the sanitation program. Since 1990 there has been no signs of mange in the reservoir population.

DISCUSSION

Use, efficacy, and toxicity of ivermectin in the Spanish ibex

The data presented in this paper refer to the first outbreak of sarcoptic mange recorded in the natural history of the Spanish ibex (León-Vizcaíno et al., 1989). There was no historical precedent of the disease in any other species of wild ruminant in Spain (Sánchez and Cuellar, 1983). Since this episode, other outbreaks of sarcoptic mange have been reported in the country, both in Spanish ibex (Pérez et al., 1992; Palomares and Ruiz-Martínez, 1993; Pérez et al., 1997), and in chamois (*Rupicapra pyrenaica parva*; Fernández-Morán et al., 1997). The latter seems to be highly susceptible to infection with *S. scabiei.* Mange in the Spanish ibex (León-Vizcaíno et al., 1999) most often leads to a chronic state (fourth phase) characterized by a remarkable decrease in the immune response (Lastras et al., 2000), severe and generalized skin lesions, and extreme weakness which leads to death.

Ivermectin has been reported as a highly potent, broad-spectrum, systemic antiparasitic drug (Campbell, 1985) which is effective against the infection produced by *S. scabiei.* Its efficacy is related not only to the dose, but also to its formulation and route of administration (Yeruham et al., 1996). Ivermectin in injectable form has been used successfully in the treatment of sarcoptic mange in domestic species (Benz et al., 1989; Manurung et al., 1990; Zamri-Saad et al., 1990; Pangui et al., 1991). Sim-

ilarly, its effectiveness has been proved in cases of sarcoptes mange in desert domestic sheep (Ibrahim and Abu-Samra, 1987) and psoroptic mange in bighorn sheep *Ovis canadensis* (Meleney et al., 1980; Kinzer, 1983). Other ways of administering the drug have been described. The drug also can be effective when administered topically (Soll et al., 1992; Lowenstein et al., 1996; Lonneux et al., 1997) or orally (Foreyt, 1993; Ruiz-Martínez et al., 1996; Yeruham et al., 1996). Wild ruminant species in zoological gardens treated with orally administered ivermectin have recovered fully, even in severe clinical cases of sarcoptic mange (Yeruham et al., 1996).

Except in experimental circumstances, cases of mange in domestic goats do not cause serious damage due to the easy application of therapeutic measures (Manurung, 1990). However, control of the scabies epizootic affecting Spanish ibex in Cazorla NP presented several problems: (1) there was no prior knowledge of the effectiveness of the treatment in that species; (2) Cazorla NP is a large, rocky mountainous territory, whose topography is very complex, where coniferous forest and typical Mediterranean woodland with abundant undergrowth are found in most areas, and where there is plenty of food for wild ruminants; and (3) many areas of natural habitat for the Spanish ibex are not easily accessed. Therefore, in order to control mange through a chemotherapeutic program using ivermectin, both oral administration of the drug and an impact activated dart shot from a helicopter, as recommended by Kinzer et al. (1983), were abandoned in favor of distance injection by means of rifle darts. Results derived from the present experimental therapeutic trial led to a recommendation to the Director of Conservation of Cazorla NP of a dosage of 0.4 mg/kg bw. The use of rifle darts to administer the treatment may be an appropriate option in the case of free-roaming wild animals. It is not necessary to capture the animals, and there is the associated problems of injury, stress, and even deaths are avoided (Kinzer et al., 1983; Foreyt, 1993; Meleny et al., 1980).

Sanitation program

There are no published references related to the use and effectiveness of sanitation programs in captive wild ruminants with sarcoptic mange with the objective of treated animals being integrated back into healthy populations. It is emphasized that in goats (Zamri-Saad et al., 1990), pigs (Courtney et al., 1989), and Spanish ibex (present study) with chronic sarcoptic mange that a favorable outcome was never achieved when the dosage was increased to 0.4 mg/kg b w, even if the treatment was repeated 14 days later. The short time between the treatments (14 days) used in this study, seems to ensure that the mites could not reproduce since their life cycle was disrupted (Yeruham et al., 1996). However, even when a satisfactory outcome was achieved, it was necessary to wait more than 4 wk before the animal showed complete parasitological and clinical recovery. This interval is considered too long because in the meantime the animal continues to be contagious. Alternatively, in those cases where infection was slight or moderate, a single dose of 0.2 mg/kg bw resulted in a cure. Manurung et al. (1990) and Zamri-Saad et al. (1990) also observed that an increase in the concentration of ivermectin did not improve the condition of the animals in their studies. However, the symptoms of sarcoptic mange in Spanish ibex disappeared earlier when the dose was 0.4 mg/kg bw. In conclusion, when there is a mass chemotherapy program in free-roaming animals, a reduction of the contagious period in the treated animals justifies the use of ivermectin at a dose level of 0.4 mg/kg bw. However, seriously affected individuals should be put down without a cure being attempted (Zamri-Saad et al., 1990).

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