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POPULATION EFFECTS OF SARCOPTIC MANGE IN BARBARY SHEEP (*AMMOTRAGUS LERVIA*) FROM SIERRA ESPUÑA REGIONAL PARK, SPAIN

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ABSTRACT: The nonindigenous Barbary sheep population (*Ammotragus lervia*) of the Sierra Espuña Regional Park (Murcia, Spain) suffered an outbreak of sarcoptic mange between 1991 and 1995, which contributed to a population decrease of 86%. This study presents the results of two population surveys conducted in 1994 and 1999 based on the fixed point and itineraries method (FPI) and the excrement count (EC) method, as well as data from demographic estimates and clinical observations conducted by the Regional Administration of Murcia. Results of surveillance for mange are given between 1992 and 1995, because no animals were observed with sarcoptic mange in 1999. Prevalence of mange peaked in 1994 and then declined. During the regression phase of the epidemic, there was a higher infection rate in males (21.9%) than in females (16.6%) or young animals (5.1%). Males over 5 yr old were the worst affected age group, followed by subadults of both sexes. Few animals had generalized lesions of mange (7%), and most individuals (72%) had lesions of moderate severity. The most common locations of lesions were the neck, head, and back. The density of Barbary sheep in the Sierra Espuña Regional Park increased from introduction in 1972 until it peaked at 13 animals/km^2 in 1991, the year when the first case of sarcoptic mange was detected. After 2 yr of the mange epidemic, the average estimated density was 1.7 animals/km^2 in 1994, which increased to 5.0 animals/km^2 in 1999. The average group size also increased from 7.9 to 19.2 animals/group between 1994 and 1999. The sex ratio, expressed as the proportion of females in the total population observed, decreased from 0.61 in 1994 to 0.49 in 1999. The reproduction rate (kids per females per year) was essentially stable (0.59 in 1994 to 0.65 in 1999). Between 1994 and 1999 the population aged, with the number of young animals (<18 mo of age) decreasing from 45.3% to 36.6% from 1994 to 1999. In the same period, the proportion of males increased 21.4% to 32.6%. We believe sarcoptic mange acted as one of the regulating factors of population density after 1991 and that currently, although no sarcoptic mange lesions were observed in the 1999 survey, there is a demographic imbalance in sex ratio, age structure, and density.

Key words: *Ammotragus lervia,* Barbary sheep, demography, epidemiology, *Sarcoptes scabiei,* sarcoptic mange.

INTRODUCTION

Barbary sheep (*Ammotragus lervia*) are from northern Africa and have characteristics in common with species in the genuses *Capra* and *Ovis*. For this reason, its current taxonomic classification is still a topic of controversy (Ansell, 1971; Valdez and Bunch, 1979). Its original distribution was northern Africa (15°N to 18°N), and currently, although its original distribution is reduced, the species is present in most mountain ranges around the Sahara Desert (Schaller, 1977; Alados and Vericad, 1993; Cassinello, 1998).

Introduction of Barbary sheep to the partially fenced uplands of Sierra Espuña (Murcia, Spain), currently the Sierra Espuña Regional Park (Sierra Espuña RP), was carried out by the now defunct Servicio de Pesca Continental, Caza y Parques Nacionales, in 1970. The 35 introduced animals (11 males and 24 females) came from various European and African zoologic parks. Barbary sheep are the only ungulates within the geographic limits of the Sierra Espuña RP. Growth of the Barbary sheep population from 1972 to 1999 is charted in Figure 1.

There are few reports concerning infectious and parasitologic disease in Barbary sheep (von Keler, 1942; Allen et al., 1956; von Brack, 1966; Middleton and Wallach, 1970; Boever, 1976; Gray and Pence,

FIGURE 1. Barbary sheep population density in Sierra Espuña Regional Park. Data are from ICONA, 1972, 1974; Brugarolas and De la Peña, 1984; TEAMSA, 1989; ETISA, 1990; the Environmental Agency of the Region of Murcia (CMARM), 1993, 1998; and this study.

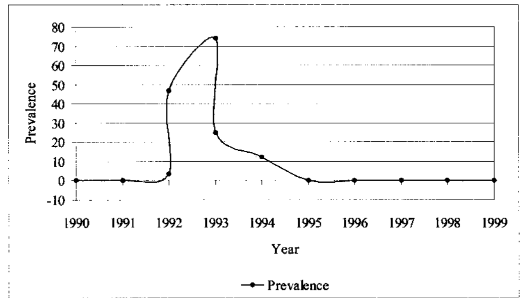

FIGURE 2. Prevalence of sarcoptic mange in the Barbary sheep population of the Sierra Espuña RP. Data are from the Environmental Agency of the Region of Murcia (CMARM) 1993, 1998, and this study.

1979), and none concerning the indigenous populations in Africa. Sarcoptic mange, caused by the *Sarcoptes scabiei* mite, has affected populations of woodland and high mountain ungulates such as Siberian ibex (*Capra ibex sibirica*) in Kirgizistan (Vyrypaev, 1985) and chamois (*Rupicapra rupicapra*), roe deer (*Capreolus capreolus*), and red deer (*Cervus elaphus*) in the Alps since the beginning of the 19th century (Kutzer, 1966; Onderscheka, 1982; Rossi et al., 1995). In Spain, mange has been detected in Spanish ibex (*Capra ibex pyrenaica*) from the Sierra de Cazorla, Segura y Las Villas, Sierra Mágina, Sierra Nevada, and other mountainous areas of Andalucía (León-Vizcaíno, 1990; Fandos, 1991; León-Vizcaíno et al., 1992, 1999; Pérez et al., 1992, 1997; Arenas et al., 2002) and in the Cantabrian mountains, where it has affected chamois populations since 1983 (Lavín et al., 1995; Fernández-Morán et al., 1997). However, there have been no reports of sarcoptic mange in free-ranging Barbary sheep.

The density of the Barbary sheep population in Sierra Espuña RP in 1991, the year the mange epidemic began, was the highest observed since its introduction and was probably over carrying capacity of the habitat; the animals were weak and the peripheral areas of the Park were shared by small domestic ruminants infested with *S. scabiei* (Ambiental, 1993). These risk factors probably influenced the start of the outbreak of sarcoptic mange and its rapid spread in the Barbary sheep population. The first cases were detected in August 1991 by officers of the Environmental Agency of the Region of Murcia and confirmed in the Infectious Diseases Laboratory of the Veterinary Faculty of Murcia University (Murcia, Spain).

The mange epidemic in the Barbary sheep lasted 5 yr (1991–95). Predictably, the prevalence of mange increased at the start (progression phase) and later decreased (regression phase). Prevalence increased from 0% to 50% in the first years (1991–92), and the highest prevalence was 74% in 1993, 18 mo after the first affected animal was found. After this peak in prevalence, the prevalence decreased to near zero in 1999 (Fig. 2).

We report the following: 1) a chronologic overview of the epidemic of sarcoptic mange in Barbary sheep in the Sierra Espuña RP, 2) an analysis of the population dynamics in the Barbary sheep since introduction, and 3) demographic characteristics of the population in 1994 and 1999.

MATERIALS AND METHODS

Study area

The Sierra Espuña RP (2°4′–2°14′N, 37°47′–37°57′W) is a protected mountain area of about 14,000 ha, included in the Betic Zone, with complex topography and steep slopes higher than 1,300 m. It is primarily medium to high mountain territory, with *Pinus halepensis* woods, shrubs, and to a lesser extent marginal cultivated plots, some of them fenced off within the park and others at its edges (Ambiental, 1993). It falls within the medium and higher meso-Mediterranean and supra-Mediterranean bio-climates (Tendero et al., 1989), and average annual temperature varies between 12.8 C and 18.4 C. Precipitation is clearly related to altitude, with an average of 277 mm/yr at the foot of the mountains and 510 mm/yr in the heart of the range. Snow falls occasionally and is significant only above 1,000–1,100 m (Ambiental, 1993).

Diagnosis of sarcoptic mange

Before and during the study begun in 1994, a parasitologic examination was made of dead and seriously ill animals culled in the selective hunting program carried out by the Environmental Agency of the Region of Murcia in order to ascertain whether *S. scabiei* was the cause of the illness observed in the animals. Parasitologic examination was conducted according to León-Vizcaíno et al. (1999). Briefly, this procedure consisted of microscopic examination of 4-cm^2 skin scrapings treated with a 10% KOH solution and incubated for 8 hr at 37 C. These were centrifuged at 800 × G for 5 min, and the supernatant was discarded. After 10 min, through a saturated glucose solution, the top layer was removed to observe mites under a stereoscopic microscope with 4× and 10× lenses. The specific identification of the parasite was performed following the descriptions given by Pence (1984).

Estimation of the Barbary sheep population

We estimated the Barbary sheep population using the fixed points and itineraries method (FPI; Bourliére, 1969). This method was adapted in order to collect data related to the existence of mange lesions in the observed animals.

Using the FPI method, the area sampled was representative of the Sierra Espuña RP as a whole. The sampling period was the same in 1994 and 1999, coinciding with the gestation and weaning periods for Barbary sheep between January and July. The FPI method was applied by dividing the study area into three sectors, placing fixed observers at high points to monitor pre-established fields while other people simultaneously crossed the same visual field, causing the animals to move. Each sector was studied on 3 consecutive days delimiting the groups sighted; this was followed by rapid enumeration of the individuals present (Bourliére, 1969) using prismatic binoculars (8 × 35, 10 × 50) and telescopes (20 × 40–70).

In 1994, the density estimation was complemented by the excrement count (EC) method (Robinette et al., 1977) in one area within the Park where there is a pine-grove that prevented FPI sampling. The EC method was carried out along three routes measuring 1 km. Each of these routes included 10 areas of 100 m^2 separated by 100 m. The circular plots were visited daily for 3 consecutive days. The average defecation figure used (10 fecal deposits·animal^{-1}·day^{-1}) was obtained from our observations of captive Barbary sheep at the Espinardo Zoological Park (Murcia) and from Neff (1968). We estimated population density according to Eberhardt and Van Etten (1956).

Data on Barbary sheep populations in 1992 and 1993 were obtained from several partial studies undertaken by the Environmental Agency of the Region of Murcia (Environmental Agency of the Region de Murcia, 1993, 1998). These data were not included in the Results; details are in the Introduction.

Sarcoptic mange lesions

The sarcoptic mange epidemic in the Sierra Espuña Barbary sheep population was monitored by telescopic observations (León-Vizcaíno et al., 1999), and the spread and intensity of the lesions caused by *S. scabiei* were recorded. The extent of the body affected by lesions of mange was categorized into three classifications: localized lesions were found only on one part of the body, regional lesions were found in multiple parts of the body, and generalized lesions were found all over the body (Jackson et al., 1983).

Demographic parameters

Demographic parameters were determined using the classification of Gray and Simpson (1979). The age groups used were Y1 (from birth to 6 mo), Y2 (6–18 mo), F1 (females from 18 mo to 3 yr), F2 (females >3 yr), M1 (males from 18 mo to 3 yr), M2 (males 3–5 yr), M3 (males 5–7 yr), and M4 (males >7 yr). In order to perform statistical analyses, the populations were categorized in five group size classes; lone animals, couples, small groups of up to 10 animals, groups of between 10 and 19 animals, and groups of >20 animals. The sex ratio was expressed as the number of adult females per male and as the proportion of adult females in the total number of adult animals (Caughley, 1977). The reproduction rate was expressed as the number of animals from birth to 6 mo of age per adult female (F1 and F2).

Statistical analyses

The estimate of the prevalence of clinical mange was obtained by comparing the number of animals with skin lesions typical of sarcoptic mange with the number of animals susceptible to infection (Thrusfield, 1995). The role of possible factors in the occurrence of mange (geographic sector, sex, age, and herd size) or the extent of lesions (sex and age) was studied using independent χ^2 tests with a significance level of $P<0.05$. The degree of association between these factors and occurrence and extent of mange was also determined using relative risk (RR) analysis and odds ratio (OR) testing. Statistical calculations were conducted using Microsoft EXCEL 2000 (1985–99 Microsoft Corporation, Redmond, Washington, USA), Statistix Version 4.0 (1985–92 Analytical Software, Tallahassee, Florida, USA), and Epi Info Versión 6.04 (1996 Centers for Disease Control and Prevention, Atlanta, Georgia, USA).

RESULTS

Prevalence of sarcoptic mange

In 1994, lesions of sarcoptic mange were observed in 43 (12.6%) of 342 animals. There were no significant differences among prevalence rates in the three geographic areas studied ($\chi^2=1.62$; $df=2$; $P=0.45$). More males were infected (16 [22%] of 73) than females (19 [16.6%] of 114). Although the relationship between sex and sarcoptic mange was not significant ($\chi^2=0.81$; $df=1$; $P=0.37$), the OR analysis suggested that males were more likely to be infected than females, with values of 1.32 ($0.72<OR<2.39$) for males compared with 0.71 ($0.42<OR<1.38$) for females. Young animals were not included in this analysis because sex could not be determined. If the same analysis is extended to include the population of young animals, where the prevalence was 5.4% (8 of 147), there was a significant relationship between the occurrence of mange and the group to which an animal belonged ($\chi^2=15.2$; $df=2$; $P=0.00$). Males had a significantly higher OR of 2.18 ($1.25<OR<3.83$) than females and young animals. The odds ratio of sighting infected young animals was significantly lower at 0.28 ($0.13<OR<0.58$).

Prevalences of mange in 1994 according to age class varied as follows: M3 (30%)>M1 (26%)>F1 (22%)>M2 (15.6%)>F2 (9.8%)>Y2 (7.7%)>Y1 (1.5%; see Table 1). The statistical relationship between the prevalence of mange and the different age groups was confirmed ($\chi^2=22.73$; $df=6$; $P=0.01$). The RR analysis showed that kids born in the same year had a statistically lower probability of having lesions of mange (0.1 [$0.01<RR<0.74$]); however, subadult males and females had a high probability of contracting mange: M1 2.29 ($1.17<RR<4.5$) and F1 2.14 ($1.2<RR<3.8$). The oldest male adults had the highest prevalence of sarcoptic mange (30%).

At least one affected animals was observed in 26 (39%) of 66 groups sighted in 1994. Ninety-three percent of the groups that contained animals with mange contained fewer than 10 animals. There was no statistical relationship between the presence of clinical mange and group size ($\chi^2=13.18$; $df=13$; $P=0.43$).

Most affected animals (72%) had a regional distribution of lesions, some (21%) had localized lesions of mange, and in only a few cases (7%) were the lesions of mange generalized (Table 2). Most males and females had regional lesions. Subadults (F1 and M1) were the age class most frequently seen with generalized lesions. Young animals had regional but not generalized lesions (Table 2). However, there was no statistically significant relationship between sex ($\chi^2=1.41$; $df=2$; $P=0.49$) or age ($\chi^2=5.27$; $df=12$; $P=0.93$) and extent of lesions. Lesions of mange were most frequently on the neck (86%), the head (76%), and the back (65%); no lesions were observed on the forelegs of any animal (Table 3).

No affected animals were found in the 1999 survey.

Demographic indices

Between 1972, the year when Barbary sheep were introduced, and 1977 there were rising annual increases in population estimates, reaching a peak of 84.7% in that

TABLE 1. Relationship between presence of scabies in 1994 and age groups of Barbary sheep in Sierra Espunña Regional Park.

Age group and sex[a]	Number	Presence of scabies			Association			
		No	Yes	Prevalence(%)	χ^2	*P*	Odds ratio (OR)	Relative risk (RR)
Y1	64	63	1	2	8.98	0.00	0.09[a] (0<OR<0.62)	0.1[a] (0.01<RR<0.74)
Y2	91	84	7	8	2.69	0.10	0.5 (0.19<OR<1.23)	0.54 (0.25<RR<1.16)
F1	63	49	14	22	6.54	0.01	2.46[a] (1.14<OR<5.27)	2.14[a] (1.2<RR<3.8)
F2	51	46	5	10	0.42	0.52	0.72 (0.24<OR<2.06)	0.75 (0.31<RR<1.82)
M1	31	23	8	26	5.43	0.02	2.74[a] (1.04<OR<7.08)	2.29[a] (1.17<RR<4.5)
M2	32	27	5	16	0.3	0.58	1.33 (0.42<OR<3.91)	1.27 (0.5<RR<3.01)
M3	10	7	3	30	285	0.09	3.13 (0.61<OR<14.2)	2.49 (0.92<RR<6.7)
M4	0	0	0	0	—	—	—	—
Total	342	299	43	12.6	—	—	—	—

[a] Y1 (birth to 6 mo), Y2 (6–18 mo), F1 (females from 18 mo to 3 yr), F2 (females >3 yr), M1 (males from 18 mo to 3 yr), M2 (males from 3–5 yr), M3 (males from 5–7 yr), and M4 (males >7 yr).

[b] Statistically significant.

TABLE 2. Distribution of lesions of sarcoptic mange in Barbary sheep in 1994 from Sierra Espuña Regional park by age and sex and groups.

Age and sex groups[a]	Localized lesions[b]		Regional lesions[b]		Generalized lesions[b]		
	Number	%	Number	%	Number	%	Number
Y1	0	0	1	100	0	0	1
Y2	2	29	5	71	0	0	7
F1	3	21	9	64	2	14	14
F2	2	40	3	60	0	0	5
M1	1	13	6	75	1	13	8
M2	1	20	4	80	0	0	5
M3	0	0	3	100	0	0	3
M4	0	0	0	0	0	0	0
Total	9	21	31	72	3	7	43

[a] Y1 (birth to 6 mo), Y2 (6–18 mo), F1 (females from 18 mo to 3 yr), F2 (females >3 yr), M1 (males 18 mo to 3 yr), M2 (males from 3–5 yr), M3 (males from 5–7 yr), and M4 (males >7 yr).

[b] Localized lesions = Lesions of mange only on one part of the body; regional lesions = lesions of mange on multiple parts of the body; generalized lesions = lesions of mange over most of the body.

year (Fig. 1). After 1977, there was a tendency of declines in increases, with some paradoxical fluctuations produced by the different methodologies employed in estimating the Barbary sheep population. Between 1991 and 1994 the mange epidemic resulted in a drastic population decline; the lowest interannual variation (−78.7%) occurred between 1992 and 1993. After 1994, when control measures for mange were adopted, there was a tendency for annual increases to grow until 1998, when again there appeared to be a tendency for the year-on-year increase to fall.

In 1994, an average density of 1.9±0.63 95% confidence interval ($CI_{95\%}$) Barbary sheep/km^2 was estimated by FP, and the average density obtained through EC was 0.77±0.57 $CI_{95\%}$ Barbary sheep/km^2. There was a significant difference between densities estimated by FPI and EC (χ^2=6.9; df=1; P=0.05). In 1999 the estimated density was based only on FPI and was 4.48±2.14 $CI_{95\%}$ Barbary sheep/km^2; the Barbary sheep density in the Sierra Espuña RP increased by 65% between 1994 and 1999.

In 1994, 66 groups were sighted; the average number of animals per group was 7.8±0.5 $CI_{95\%}$. In 1999 sightings were made of 109 groups with an average size of 19.2±0.8 $CI_{95\%}$ Barbary sheep/group. Between 1994 and 1999 groups of over 20 animals increased by 92%, whereas the sighting frequency of all herds under 10 animals decreased.

Neither of the sample periods in Sierra Espuña RP was during the Barbary sheep's mating season, which is normally between October and December. In 1994 the existence of segregation of the sexes was significant (χ^2=44.23; df=4; P=0); 70% of the groups contained only one sex of adult animal. In 1999 there was also significant sexual segregation from group to group (χ^2=92.07; df=4; P=0), because most groups contained only one sex of adult (91.7%; 100/109). The mixed-sex herds

TABLE 3. Location of lesions of sarcoptic mange on Barbary sheep from Sierra Espuña Regional Park in 1994.

	Head	Neck	Shoulder	Back	Flank	Croup	Foreleg	Leg
Presence	33	37	17	28	4	3	0	1
Absence	10	6	26	15	39	40	43	42
Frequency	77	86	40	65	9	7	0	2

were usually the biggest, containing more than 20 animals (30%).

In 1994, the total frequency of sighting males was 21.3%, of females was 33.3%, and young animals accounted for 45.3% of the population. In 1999, young animals were estimated to comprise 36.6% of the population, females 31.9%, and males 32.5%. The sex ratio in 1994 was estimated at 1.5 females per male (P_f=0.61±0.07 $CI_{95\%}$). In 1999 the sex ratio was estimated at 1.0 females per male (P_f=0.49±0.039 $CI_{95\%}$).

In 1994 the reproduction rate was estimated at 0.59±0.15 $CI_{95\%}$, taking into account young animals from group Y1 and all adult females. In 1999 the reproduction rate was estimated at 0.65±0.08 $CI_{95\%}$ based on identical criteria.

DISCUSSION

For establishment and management of natural reservations, it is important to know about the illnesses of the resident species and their consequences as well as for the domestic animals with which they can come into contact and for human beings. It also is important to know the causes and factors that can disturb the balance between births and deaths in populations of wild species. Sarcoptic mange is the most severe infection in European wild ruminants (Rossi et al., 1995; León-Vizcaíno et al., 1999). In the first wave of the epidemic studied here, the impact of the disease on naive populations of Barbary sheep was dramatic with almost 100% morbidity rates and high mortality. Epidemics of sarcoptic mange may have severe consequences on wild ruminant populations in a short period of time (Miller, 1985; Rossi et al., 1995; Yeruham et al., 1996; Fernández-Morán et al., 1997; León-Vizcaíno et al., 1999). Intervals between successive waves of mange last 10–15 yr, and subsequent epizootics have less severe population impacts (Rossi et al., 1995). This may be explained by interaction between the level of immunity in the population, natural host resistance, and selection of less pathogenic strains of the causal agent (Pence et al., 1983).

Sarcoptes scabiei may have been introduced to the Sierra Espuña RP via domestic goats; a few weeks before the mange outbreak was detected in Barbary sheep, dead domesticated goats were found within the area. Introduction of mange by domestic animals has been suspected in epidemics in other wild animals such as Spanish ibex (León-Vizcaíno et al., 1999); Siberian ibex in Kirghizstan (Vyrypaev, 1985); and chamois (Fernández-Morán et al., 1997).

The sarcoptic mange outbreak in the Barbary sheep of the Sierra Espuña RP took place between 1991 and 1995, reaching its maximum prevalence in 1993 and then declining until it virtually disappeared in 1995. In sarcoptic mange epidemics studied in wild ruminants, after the first outbreak the population is so greatly reduced that there is a phase of epidemic silence, with subsequent fluctuations in disease occurrence without reaching a threshold of 5% prevalence. The duration of an outbreak of sarcoptic mange is variable, depending on the size of the population and the probability of contact among groups. Having confirmed in 1999 that no Barbary sheep had clinical sarcoptic mange in the Sierra Espuña RP, we assert that in 1995 in this population it began a phase of epidemic silence. This is similar to the epidemic pattern observed in the Spanish ibex population of Sierra Mágina (Pérez et al., 1992), and up to the present day sarcoptic mange is not endemic in Spanish ibex in Sierra Nevada (Pérez et al., 1997), Serranía de Ronda (Arenas et al., 2002), or Sierras de Cazorla, Segura y Las Villas (León-Vizcaíno et al., 1999); in Siberian ibex in Kirghizstan (Vyrypaev, 1985); or in chamois in the Alps (Rossi et al., 1995) or in the Cantabrian mountains (Fernández-Morán et al., 1997).

The apparent self-limiting nature of the sarcoptic mange outbreak in the Barbary sheep of Sierra Espuña RP was influenced by the extreme decrease in population, the absence of alternative hosts that could maintain the mites, the extreme weather conditions since 1994 (with years of extreme drought and the highest temperatures of the last 20 yr in 1994 and 1995), and the management intervention carried out by the Regional Environmental Agency. This last factor consisted, in summary, of hunting and elimination of affected individuals, reduction of the vulnerable population through capture and quarantine, and the induction of resistance to mange through administration of food containing ivermectin.

Adult male chamois appear more vulnerable to mange than other sex and age groups (Rossi et al., 1995), and prevalence increases with age (see also Vyrypaev, 1985; León-Vizcaíno et al., 1992, 1999; Pérez et al., 1992, 1997; Rossi et al., 1995). These patterns were also observed in the Barbary sheep of Sierra Espuña.

Most affected animals had regional skin lesions. The large proportion of affected animals with moderate lesions, together with the relatively low prevalence, leads to the conclusion that morbidity and mortality of the disease had decreased. In earlier phases of the epidemic, although exact information is not available, it is reasonable to assume that lesions were severe, because morbidity and mortality was high.

The sarcoptic mange lesions observed in Sierra Espuña Barbary sheep were found most frequently on the neck, head, and back, and less frequently on the limbs and extremities. This pattern has been observed elsewhere in domestic (Jackson et al., 1983) and wild (Onderscheka, 1982; Fernández-Morán et al., 1997; León-Vizcaíno et al., 1999) ruminants.

The evolution of the mange epidemic in the free-ranging Barbary sheep of Sierra Espuña was monitored by observations of animals through telescopes. This method of evaluating prevalence has been used in other sarcoptic mange epidemics in wild animals (Vyrypaev, 1985; Pence and Windberg, 1994; Rossi et al., 1995; Fernández-Morán et al., 1997; León-Vizcaíno et al., 1999; Arenas et al., 2002). Arenas et al. (2002) estimated 94% sensitivity for monitoring sarcoptic mange lesions using telescopes in their study of mange Spanish ibex. However, it is not possible to distinguish healthy animals from those that are in the initial phase of the illness.

The drop in the Barbary sheep population observed between 1989 and 1991 (Fig. 1) was not the result of disease, because there was no evidence of abnormal mortality. Rather there was almost certainly an overestimation of the population in 1989 (TEAMSA, 1989) and an underestimation in 1990 (ETISA, 1990). Therefore the greatest population density of Sierra Espuña RP Barbary sheep was observed in 1991 and 1992, and it was from that time onward that the drop in population began as a result of the sarcoptic mange epidemic.

Factors that may have predisposed the Sierra Espuña RP Barbary sheep population to a disease outbreak were the small number of animals (20) used to establish the population and the fact that their origins were from animals at zoologic parks, which may have resulted in reduced genetic variability and possible increased susceptibility to illnesses (Garten, 1976; Ralls et al., 1979); the fact that animals could not disperse once the carrying capacity of the habitat was reached because of a fence, resulting in overgrazing and degradation of the vegetation, leading in turn to a worsening of the physical condition of the animals (Alados and Escós, 1990); and the extreme weather conditions typical of a semiarid climate.

The epidemic of sarcoptic mange in the Sierra Espuña Barbary sheep lasted 5 yr, after which it entered a phase of epidemic silence, and the Barbary sheep population began to recover as of 1995 (Fig. 1). Even so, year-to-year population growth began to decrease in 1997, a fact that could be largely due to the limitations of the habitat in terms of the food available, but not to sarcoptic mange, because no Barbary sheep have been detected with sarcoptic mange lesions since 1999.

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