Recommendations for the management of sarcoptic mange in free–ranging Iberian ibex populations

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Abstract

Recommendations for the management of sarcoptic mange in free–ranging Iberian ibex populations. In recent decades, sarcoptic mange has become the main driver of demographic changes in Iberian ibex (*Capra pyrenaica*) populations in the Iberian Peninsula. Given this species' economic and ecological importance, priority must be given to management measures aimed at limiting the effects of this disease. However, despite the wealth of research on sarcoptic mange in ibex, no common patterns of action are yet available to manage this disease under field conditions. The lack of national and international protocols aimed at controlling sarcoptic mange has favoured the spontaneous emergence of various disease management initiatives in Spain. However, very little information is available concerning this trend and what there is tends to be available only as 'grey literature' or is consigned to the memory of local observers. Traditional strategies designed to combat this disease include the administration of medicated feed and the non–selective culling of mangy ibex. Here, we propose a management approach that takes into account aspects relating to the ecology and conservation of ibex populations, as well as public–health–related factors. Our recommendations are based on knowledge of the disease and host–parasite interaction, and aim to promote long–term advances in its control. Moreover, we discuss the efficacy of the measures traditionally used in mange management. The overall aim is to encourage debate between wildlife managers and motivate the development of alternative management strategies.

Key words: *Capra pyrenaica*, Conservation, Management strategies, *Sarcoptes scabiei*, Wild populations

Resumen

Recomendaciones para el manejo de la sarna sarcóptica en poblaciones silvestres de cabra montés. En las últimas décadas, la sarna sarcóptica se ha convertido en la principal causa de los cambios demográficos en las poblaciones silvestres de cabra montés (*Capra pyrenaica*) de la península ibérica. Dada la importancia ecológica y económica de esta especie, se debe dar prioridad a las medidas de gestión destinadas a limitar los efectos de esta enfermedad. Sin embargo, a pesar del gran número de estudios que existen sobre la sarna sarcóptica en la cabra montés, actualmente no hay ningún protocolo de actuación común para el manejo de esta enfermedad sobre el terreno. La ausencia de protocolos nacionales e internacionales destinados a controlar la sarna sarcóptica ha favorecido la aparición espontánea de diversas iniciativas de gestión en España. Sin embargo, existe muy poca información sobre esta tendencia y la que hay solo suele estar disponible en la literatura gris o en la memoria de los observadores locales. Algunas de las estrategias tradicionales diseñadas para combatir esta enfermedad son la administración de piensos medicados y el sacrificio generalizado de los animales afectados. En este trabajo, proponemos un enfoque de gestión que tenga en cuenta aspectos relacionados con la ecología y la conservación de la cabra montés, además de factores relacionados con la salud pública. Nuestras recomendaciones se basan en el conocimiento de la enfermedad y la interacción entre el parásito y el hospedador y tienen por objeto impulsar progresos a largo plazo en su control. Además, analizamos la eficacia de las medidas utilizadas tradicionalmente en el manejo de la enfermedad. El objetivo general es fomentar el debate entre los gestores de fauna silvestre y motivar la elaboración de estrategias de gestión alternativas.

Palabras claves: *Capra pyrenaica*, Conservación, Estrategias de gestión, *Sarcoptes scabiei*, Poblaciones silvestres

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Introduction

Awareness of the importance of actively managing infectious diseases in wild animals is a relatively novel phenomenon. Until recently, the general attitude was that 'nature can manage on its own'. However, the presence of humans and the enormous pressure they exert on the environment as a means of satisfying their requirements distorts this natural balance and artificial control measures are needed (Lyles and Dobson, 1993). Two good examples of such distortions are the elimination of large predators and the loss of biodiversity (Packer et al., 2003; Keesing et al., 2006). In many zones, this has led to an unsustainable overabundance of wild animals in their chosen habitats, which creates ideal conditions for the flare–up of disease (Rossi et al., 2005; Gortázar et al., 2006; Vicente et al., 2007). If these diseases are zoonotic in character or imply a threat to human economic activities, human action becomes inevitable as, for example, in the cases of rabies in wild carnivores (Pastoret and Brochier, 1999), classical swine fever in wild boar (Kaden et al., 2000) and tuberculosis in badgers (Woodroffe et al., 2005). Furthermore, the emergence of virulent forms of infectious agents or highly susceptible hosts may also jeopardize the structure of wild populations (Woodroffe, 1999), as occurred in the case of sarcoptic mange caused by the *Sarcoptes scabiei* mite.

In the Iberian ibex (*Capra pyrenaica*), sarcoptic mange is at the root of the most serious demographic changes affecting this mountain ungulate in the Iberian Peninsula (Fandos, 1991; Pérez et al., 1997), to the extent that representative populations have become severely depleted and others are currently threatened (e.g. ibex populations in the Ports of Tortosa and Beceite and in the Game Reserve of Muela de Cortes) (unpublished data). Although sarcoptic mange is a constant threat to all populations of this mountain ungulate, currently this disease has not curbed the demographic trend of this species. However, the ecological, economic and social importance of the ibex (Granados, 2001), together with the sanitary risks that sarcoptic mange poses, obliges authorities and wildlife managers to instigate management control measures. One of the great inherent difficulties is that, like other infectious diseases (Kock et al., 2018), mange epidemics break out unexpectedly, often for obscure reasons (Pence and Ueckermann, 2002). As well, the pathogenesis of sarcoptic mange (in terms of morbidity, mortality and population effects) generally varies greatly from one affected area to another (Fandos, 1991; Mörner, 1992; Pérez et al., 1997; Fernández–Morán et al., 1997) and its effects are difficult to predict in affected populations for the first time. Given that the eradication of this disease is practically impossible (Wobeser, 2002), attempts are made to reduce its impact to 'tolerable' levels using a variety of control strategies areas; as such, management tasks designed to combat this disease are extremely complex.

Despite the amount of research that has been carried out on sarcoptic mange in the ibex, no common evidence–based management strategy designed to combat this disease under field conditions exists. This absence of any national or international protocol for sarcoptic mange has led to the emergence in Spain of spontaneous disease management initiatives that lack any consensus regarding which strategies are the most appropriate. Traditional strategies include the administration of medicated feed or the non–selective culling of mangy ibex. However, many management techniques generate serious social conflicts between animal rights activists, hunters and the local environmental agencies in charge of hunting activities. Furthermore, very little information is available on this question and what is available is generally either 'grey literature', that is, unpublished reports and conference proceedings, or it simply resides in the memories of local observers (Sánchez–Isarria et al., 2007a, 2007b). For this reason, we believe that it is essential to draw up a series of proposals for improved management and control of the spread of mange in the Iberian ibex.

We believe that the selection of the most appropriate management techniques requires a clear understanding of the cause and ecology of this disease, as well as full knowledge of the course of the disease in individual ibex and the population biology of the parasite–host interaction. In light of the four categories used for the management of wildlife diseases (prevention, control, eradication and doing nothing i.e. *laissez–faire*) (Wobeser, 1994, 2002; Artois et al., 2001, Artois, 2003), here we propose action that lies halfway between *laissez–faire* and control, given that prevention and eradication under field conditions is an extremely complex task. We use published scientific evidence on sarcoptic mange in the ibex to develop a more 'ecological' approach to the management of this disease, which we believe is the best strategy for both the conservation of the species and future prevention. Additionally, we discuss the effectiveness of the measures traditionally used in mange management. We hope that this work will stimulate a debate among wildlife managers and motivate the development of alternative management strategies. Our aim is to promote a consensus regarding the best measures to adopt when confronted with sarcoptic mange, while ensuring optimal conservation of ibex.

Preliminary considerations

Initially, it is important to highlight certain aspects of the disease that will serve as premises in control strategies: (1) As a parasitic disease whose main mode of transmission is direct contact, sarcoptic mange can be categorized as a density–dependent process (Pence and Windberg, 1994; León–Vizcaino et al., 1999). (2) The clinical course in affected individuals (and therefore its effect on populations) is variable (Fandos, 1991; Górtazar et al., 1998; González–Candela et al., 2004). Effects will be conditioned by intrinsic factors relating to each individual and/or population (sex, age, genetics, health status, previous contact with the mite, etc.) and/or extrinsic factors (time of year, population density, infective dose, availability of trophic resources, etc.) (Rossi et al., 2007; Sarasa et al., 2010; López–Olvera et al., 2015; Pérez et al., 2017). (3) Except in residual or highly fragmented populations, in which the capacity to respond to changes is low (Skerratt, 2005), although mortality may at first be high (in many cases favoured by elevated densities), initial appearances can be deceptive and have no significant long–term effects on population dynamics (Pérez et al., 1997; Little et al., 1998).

Given these considerations, the management measures taken to limit the effects of sarcoptic mange can be either active or pro–active.

Active management refers to actions applied to the affected ibex population and/or the environment if sarcoptic mange is present in the ibex population and there is a desire to reduce its impact. Given its speed and effectiveness, host density reduction by culling is the most commonly used method (Sánchez–Isarria et al., 2007a). In the case of directly transmitted infections, population reduction is based on the epidemiological theory that –regardless of the severity of lesions– the per capita rate of disease transmission and the prevalence of the disease will grow as the population increases (Wobeser, 2002; Maxwell et al., 2013). The use of medicated feed containing Ivermectin or other macrocyclic lactones placed at different points in the wild has also been used as a mange management strategy in free–ranging ibex populations (Sánchez–Isarria et al., 2007b).

Pro–active management measures include actions that aim to prevent future outbreaks of the disease and/or reverse the effects of mange epidemics. This group of techniques includes research, habitat improvement and the setting up of infrastructure. Furthering knowledge of pathological, immunological and epidemiological aspects of this disease improves our understanding of its development and helps determine in a coherent fashion the best measures for reducing its impact (Espinosa, 2018). Other important preventive measures in mange management in ibex include the restoration of pastures, the sowing of forage in time of scarcity or the modification of drinking fountains, aimed at strengthening the health status of the population; the veterinary control of livestock and safe translocations of ibex, to reduce the risk of mange transmission between domestic herbivores and ibex and/or disease–free ibex populations (Fandos 1991; Pérez et al., 1996); or the establishment of a stock reservoir of ibex in order to combat massive mortality outbreaks or for the strengthening some of ibex populations (Espinosa et al., 2017b).

Management proposals against sarcoptic mange and discussion

Here we suggest a series of alternative strategies for managing sarcoptic mange in free–ranging ibex populations. The selection of the most appropriate management technique requires a clear understanding of the ecology of the disease (including how the disease affects the individual), as well as intimate knowledge of the population biology of the parasite–host interaction. In the case of mange in ibex, we propose selective, less invasive action based on scientific evidence that, compared to traditional management measures, will provide more long–term benefits and better protection against future mange outbreaks.

In the interaction between sarcoptic mange and the Iberian ibex, four pathological phases or periods have been used to characterize the severity of infestations, according to the percentage of skin surface affected: 0, ibexes without skin lesions; 1, skin surface affected < 25 %; 2, skin surface affected > 25 and < 50 %; 3, skin surface affected > 50 and < 75 %; and 4, skin surface affected > 75 %) (León–Vizcaíno et al., 1999; Pérez et al., 2011). Given this, our management proposals focus exclusively on the selective culling of ibex in the chronic or final phases of the disease (phases 3 and 4). We rule out massive culling in mangy ibex populations and attempts to control the disease in the wild using pharmacological treatments. As we argue below, we believe that selective culling of ibexes in the final phases of the disease is the most appropriate and most reasonable measure for tackling sarcoptic mange in the ibex.

Selective removal of infested ibexes

From a clinical point of view, under natural conditions the multi–systemic clinical picture is severe and entails a very marked reduction in body condition, disorders of haematological and biochemical parameters (Pérez et al., 2015), septicaemic processes (Espinosa et al., 2017d), oxidative stress phenomena (Espinosa et al., 2017c), and an increase in inflammation biomarkers causing tissue damage in dermal and non–dermal tissues (Raéz–Bravo et al., 2015; Espinosa et al., 2017d), all of which greatly reduce survival possibilities and/or hamper the recovery of ibexes in chronic phases of disease. For ethical and humanitarian reasons, the ending of the suffering of infected animals is necessary. In addition, ibex that have reached these stages of the disease can be a direct or indirect potential source of infestation for the rest of the population (Arlian et al., 1984; Pérez et al., 2011). Thus, unlike a non–intervention (*laissez–faire*) strategy (Wobeser, 2002), our low–level intervention approach will help reduce the risks of mange transmission within a population.

Sarcoptic mange has side–effects that, in final phases of the disease, negatively affect the reproductive physiology of both male and female ibex (Sarasa et al., 2011; Espinosa et al., 2017a) and hinders their reproductive success. This makes them ineffective in prolonging the species and therefore unable to transmit to their offspring any type of response developed against the disease. In addition, given that mange is transmitted mainly by direct contact, recently born young are likely to be infected and to increase the affected population. This assumption is based on the observation of very young ibex with sarcoptic mange in herds with mangy adult specimens (Espinosa et al., 2017a), as well as the finding of mangy carcasses of juvenile ibex (J. E. Granados, pers. comm.).Thus, severely ill ibexes, with a low reproductive capacity and with a high risk of spreading the infestation to the rest of ibex population are determining factors to selectively remove these individuals and thus contribute to the control of the disease.

Fig. 1. Iberian ibex with sarcoptic mange: A, female ibex in early phases of the disease; B, male ibex with severe sarcoptic mange. Unlike the previous animal, according to our management proposals, this ibex should be removed from the ibex population.

Fig. 1. Cabras montesas afectadas por sarna sarcóptica. A, hembra de cabra montés en las primeras fases de la enfermedad; B, macho de cabra montés con sarna sarcóptica intensa. A diferencia del animal anterior, de acuerdo con nuestras propuestas de manejo, este ejemplar debería ser eliminado de la población.

In all cases, the selective culling of these ibex must be carried out whenever possible by specialized staff using firearms. Capture using anaesthetic darts or systems of physical restraint that involves the pharmacological administration of a lethal drug –and therefore further manipulation– is a far more laborious and costly process (e.g. additional staff, the transfer of carcasses for incineration, etc.) with greater chances of failure on the welfare ground (due to additional capture–related stress; López–Olvera et al., 2009). The thorough disposal of the mangy skin of culled ibex reduces the possibilities of disease contamination and transmission and, unlike laissez–faire strategies (Wobeser, 2002) that advocate leaving dead ibex in the wild, eliminates a risk factor for the rest of the ibex population and for sympatric species.

Effects of massive lethal control of sarcoptic mange

Attempts to reduce or eliminate sarcoptic mange from the population by culling all mangy ibex– regardless of the severity of lesions– may also have unintended consequences on the population. No effective results for this type of management measure have ever been reported. For example, the spread of mange in Northern chamois (*Rupicapra rupicapra*) in the Eastern Alps (Italy, Austria and Slovenia) and Southern chamois in the Cantabrian Mountains (Spain) could not be controlled by culling visibly infected individuals (Meneguz et al., 1996; Fernández–Morán et al., 1997). One of the problems of this technique is that, in the event of epizootic outbreaks of disease, most of the large–scale culls take place before epidemiological studies of the response of the population to the disease are performed and so do not discriminate between ibex in regression stages and those that are resistant to the disease. We believe that ibex in the initial and intermediate stages of the disease (phases 1 and 2) (León–Vizcaíno et al., 1999; Pérez et al., 2011) should never be removed from the population (fig.1).

In the initial stages of the disease (Phases 1 and 2), the identification of sarcoptic mange with binoculars or telescopes can be confused in ibexes that, although without being parasitized by *S. scabiei*, show alterations of the coat due the seasonally heavy shedder (Valldeperes et al., 2019).

Experimental infestations carried out on ibex from the Sierra Nevada Natural Space showed a wide variety of clinical responses varying from animals that progressed to severe or chronic phases to others that developed self–limiting clinic processes with mange lesions covering less than 50 % of the body surface, spontaneous regression lesions (move from phases 3–4 to 2–1) and even full recovery (Espinosa et al., 2017c) (fig. 2). Furthermore, scientific evidence show that a considerable proportion of mangy ibex recover naturally (Alasaad et al., 2013). Similar results were obtained in experimentally infested Northern chamois (*R. rupicapra*) in the Alps (Menzano et al., 2002)

As well, the loss of genetic diversity from the population through the removal of resistant ibex or those in a recovery stage can have long–term negative consequences and even give rise to future, more severe epidemics due to a loss of herd immunity (Ebinger et al., 2011).The culling of diseased animals can even select for increased virulence as it means that there will be a greater number of relatively more susceptible hosts available for pathogens; this, in turn, stimulates pathogens to transmit more quickly to susceptible hosts to avoid being culled along with their hosts (Choo et al., 2003). Another counterproductive consequence is that a reduction in population size by culling is often offset by the effects of compensatory reproduction and immigration (Caughley and Sinclair, 1994). Social structure disruption with increased movement and therefore increased contact rate (Donnelly et al., 2006) may lead to depopulation. This has been reported in the case of bovine tuberculosis in cattle and European badgers (*Meles meles*) (Woodroffe et al., 2006).

Non–lethal control: drug treatment of infested animals

The clinical management of wildlife is becoming increasingly frequent but is usually conducted only at the population level since individual treatment is largely impractical. Nonetheless, in tiny populations facing high extinction risks, vaccination and individual treatment may help manage a variety of infections (Wodroffe, 1999; Wobeser, 2002). For example, successful treatment against sarcoptic mange in a small population of Arctic foxes (*Alopex lagopus*) and individual treatment with anthelmintics in red grouse (*Lagopus lagopus scoticus*) have been reported (Dobson and Hudson 1992; Bornstein et al., 2001). Usually, it is impossible to capture and treat an entire population and so not all management programs have obtained conclusive results. Despite showing positive effects at an individual level in some cases, data on long–term population effects or re–infection rates of treatment against mange in Mednyi arctic foxes (*Alopex lagopus semenovi*), cheetahs (*Acinonyx jubatus*) and mountain gorillas (*Gorilla beringei beringei*) are inconclusive (Mwanzia et al., 1995; Goltsman et al., 1996; Kalema–Zikusoka et al., 2002). In the same way, following field trials the use of Ivermectin 'bio–bullets' to treat bighorn sheep (*Ovis canadensis nelsoni*) for psoroptic mange was rejected as a realistic management tactic (Jessup et al., 1991). If, in tiny populations, pharmacological treatment as a management strategy proves not to be totally efficient, in larger populations or over larger areas, such intervention may be inappropriate, unsustainable or simply impractical. Part of the problem in this regard is that the drugs that are used have often not been tested extensively in free–ranging wild animals, so that their actual efficacy is unknown. In addition, there is no consensus between the dose of drug administered and the severity of the infestation of the treated animals. Most of the studies consulted on attempts to control mange in free–ranging populations based their outcomes upon a few recaptured or remotely observed individuals and the long–term effects at the population level were in most cases inconclusive (see table 1).

In the Iberian Peninsula, attempts to control sarcoptic mange outbreaks in ibex and chamois (*Rupicapra pyrenaica parva*) (Fernández–Morán et al., 1997) by dispersing feed treated with Ivermectin is a commonly used management strategy. Taking into account results in other species (Rowe et al., 2019), we believe that this strategy is impractical as to date there is no proof as to its effectiveness. In fact, treatment with Ivermectin is likely not warranted until designed studies have demonstrated its efficacy in free–ranging Iberian ibex populations.

Captive mangy ibex treated with Ivermectin via subcutaneous injection needed four weeks of treatment before complete parasitological and clinical recovery. However, no positive results were obtained in chronically ill ibex (León–Vizcaíno et al., 2001), similarly as in other species (Skerratt, 2003; Kido et al., 2014). We consider that in ibex with severe sarcoptic mange the multi–systemic complications derived from the action of the mites (Espinosa et al., 2017d, 2017c) require additional treatment if the animal is to completely recover, which include the provision of intravenous fluids, antimicrobials and high–caloric nutrition. In free–ranging ibex, parenteral antiparasitic treatment is considered impractical for economic reasons, while the capture and handling of severely affected ibex for treatment purposes may often result in short–term mortality (López–Olvera et al., 2009).

When attempting to control sarcoptic mange epizootics in ibex by administrating drugs orally, it must be taken into account that many areas of the natural habitat of the ibex are large and inaccessible (Acevedo and Cassinello, 2009). Therefore, it may never be possible to successfully implement long–term sarcoptic mange control in free–ranging ibex populations since dispensing drugs in this fashion implies no control of doses, no guarantee of repeated individual treatment, and very little acquired knowledge of effective therapeutic doses. It is also important to know whether other sympatric species act as reservoirs of the disease and contribute to its maintenance in the target host population, as shown in other multi–species models (Gakuya et al., 2012).

We also believe that other ecological, ethical and public health issues must be addressed when contemplating the free dispensing of drugs in the natural environment (Artois et al., 2011; Crozier and Schulte–Hostedde, 2014). For example, the distribution of medicated feed at specific points can involve the aggregation of animals and therefore greater contact and an increase in infestation rates (Anderson and May, 1978). Environmental pollution via excreta with antiparasitic residues can cause a loss of biological diversity amongst invertebrate, vertebrate and microbial fauna, which in turn can be competitors in exogenous phases of other parasites (Verdú et al., 2018). Another important aspect is the development of acquired resistance by parasites to the chemicals present in the medication, which, due to the selective pressure in resistant organisms, is a clear risk in any program dependent upon the continued and widespread use of chemotherapy (Wobeser, 2002). This is significant not only for the treatment of mange in the ibex but also for the management of disease in domestic livestock and even in humans. Other less well–known effects, such as the teratogenic effects of Ivermectin intake during pregnancy or lactation, must also be taken into account (Bialek and Knobloch, 1999).

The abuse of antiparasitic drugs can also affect the nature of the parasite–host interaction. For example, it is well known that previous contact with the mite induces a more intense and effective immune response in re–infestations (Sarasa et al., 2010). Thus, host–parasite relationships can be modified by continuous

Fig. 2. Iberian ibex experimentally infested with *Sarcoptes scabiei* showing a self–limiting process. A, development of the first lesions in the inoculation area (inter–scapular region); B, extension of the lesions over 50 % of the body surface; C, regression of the lesions, leaving small lesion centres on the rump; D, complete recovery of the animal with the disappearance of mangy lesions. To date this animal has not developed any further lesions or clinical signs of disease (Espinosa et al., 2017c).

Fig. 2. Cabra montés infectada experimentalmente con Sarcoptes scabiei *que muestra un proceso de infección autolimitante. A, aparición de las primeras lesiones en la zona de inoculación (región interescapular); B, extensión de las lesiones en el 50 % de la superficie corporal; C, regresión de las lesiones, que dejan pequeños centros de lesión en la grupa; D, recuperación completa del animal con la desaparición de las lesiones sarnosas. En la actualidad, este animal no ha vuelto a manifestar lesiones ni signos clínicos de la enfermedad (Espinosa et al., 2017c).*

interference to the immune system as a result of the lack of sufficient parasitic antigens able to produce efficient and protective stimulation (Pedersen and Fenton, 2015). Therefore, the development of a correct immune response and the appearance of resilient ibex may be delayed or interrupted. Even if treatment does manage to eliminate mites from mangy ibex, recovered animals will not acquire long–lasting immunity and re–infestation may occur (Pederson, 1984; Wobeser, 2002). Another unintended consequence of the non–selective use of antiparasitic drugs in the wild is the possible modification of the balance with other parasites in both healthy and mangy ibex (Pérez et al., 2003; Thomas et al., 2005). Based on the above, we believe that in free–ranging species the application of uncontrolled antiparasitic treatment is inappropriate since evidence of proven efficacy is lacking and there is no solid scientific base to support its use as a management measure. Until such scientific support is obtained, this type of management measure should be limited exclusively to the control of sarcoptic mange in captive wildlife (Rowe et al., 2019) or domestic livestock sharing territory with the ibex, thereby ensuring the safe and efficient control of a significant risk factor for the ibex population (Granados, 2001). On the other hand, it will be interesting to evaluate the efficacy of the new generation of isoxazoline parasiticides as an alternative to the use of macrocyclic lactones in the treatment of sarcoptic mange in ibex (Van Wick and Hashem, 2019). For more information on the success of such treatment in wild species, treated animals will have to be fitted with radio–collars to guarantee better individual monitoring.

Finally, we believe that, bearing in mind the considerations outlined above, the culling of mangy ibex in chronic phases is justified. The public can be

Table 1. Summary of attempts to treat mange in free–ranging wildlife and reported results. Treatments in captive wildlife are excluded: I, infestation (OM, Otodectic mange; PM, Psoroptic mange; SM, sarcoptic mange).

Host species	I	Severity	Treatment and doses
Mednyi artic fox (*Alopex lagopus semenovi*)	OM	Unreported	Alugan spray and ivermectin Unknow doses
Cheetah (*Acinonyx jubatus*) and others	SM	Mild to severe	Ivermectin: one doses (200 µg/kg SC)
Bighorn sheep (*Ovis canadensis*)	PM	Mild or severe	Ivermectin 'bio–bullet'. Doses unknown strategy
Red fox (*Vulpes vulpes*)	SM	Unreported	Ivermectin; one doses (300 µg/kg SC)
Southern hairy nosed wombat (*Lasiorhinus latrifrons*)	SM	Mild or severe	Ivermectin: one doses (300 µg/kg SC)
Bare–nosed wombat (*Vombatus ursinus*)	SM	Mild to moderate	Ivermectin: two doses (400–800 µg/kg SC) + Amitraz: one doses (0.025% topical wash)
Mountain gorilla (*Gorilla beringei beringei*)	SM	Mild to severe	Ivermectin: one doses (170–670 µg/kg IM) + Antibiotic and vitamin supplements
Hanuman langur (*Semnophitecus entellus*)	SM	Moderate	Tebrub: 30 doses (250 mg PO) Mebhydrolin: 30 doses (25 mg PO) Ivermectin: one doses (1 mg/kg SC) Chlorpheniramine maleate: one dose (10 mg SC)
Vicuña (*Vicugna vicugna*)	SM	Mild to severe	Ivermectin (unknown doses
Giraffe (*Giraffa camelopardis*)	SM	Moderate to severe	Unreported
Agile wallaby (*Macropus agilis*)	SM	Moderate	Ivermectin: two doses (300 µg/kg SC)
Gorilla (*Gorilla beringei beringei*)	SM	Severe	Ivermectín: two doses (200 mg/Kg SC) + Antibiotic
Iberian ibex (*Capra pyrenaica*)	SM	Mild to severe	Foxim: two doses (500 mg/l topical wash) + Ivermectin: two doses (02 mg/kg SC)
Koala (*Phascolarcos cinereus*)	SM	Unreported	Amitraz: two doses (0.025% topical wash)

Tabla 1. Resumen de los intentos de tratar la sarna en especies de fauna silvestre y resultados obtenidos. Quedan excluidos los tratamientos en cautividad: I, infestación (OM, sarna otodéctica; PM, sarna psoróptica; SM, sarna sarcóptica).

Effects on population	Reference
Non–significant increase in cub survival; effect on population viability unknown	Goltsman et al. (1996)
Recovery of some treated individual; inconclusive long–term population effects	Gayuka et al. (2012)
Not reported, but dismissed as a management	Jessup et al. (1991)
Ineffective results both in the individual and in the population	Newman et al. (2002)
Effective treatment only in animals with mild mange; population effects unknown	Ruykys et al. (2013)
Recovery of some treated individual; population effects unknown	Skerratt et al. (2004)
Recovery of all affected animals and mange control in the gorilla population	Kalema–Zikusoka et al. (2002)
Recovery only of animals with parenteral treatment; population effects untested	Chhangani et al. (2001)
Inconclusive treatment results	Gómez–Puerta et al. (2013)
Treated animals recovered. Certain success at the population level	Alasaad et al. (2012)
Successful on an individual level; population effects not evaluated	McLelland and Youl (2005)
Successful on an individual level and mange control in the gorilla population	Graczyk et al. (2001)
Recovery of some treated mild mangy individual. Dismissed as a management strategy at the population level	León–Vizcaíno et al. (2001)
Complete success at the individual and population level	Brown et al. (1982)

convinced of the need to remove some specimens without culling all affected ibex. Using solid arguments and without applying extreme management measures the aversion generated by human intervention in the control of the disease in wildlife can be minimized.

Conclusions

Parasites are natural parts of ecosystems and for this reason the presence of parasites in hosts does not necessarily imply that these wild populations are in danger of disappearing. Wildlife is a societal resource and provides ecological services that are vital for sustaining economies and human health. However, sometimes (as in the case of sarcoptic mange in Spanish ibex) a parasitic disease causes the death of a part of the population, thereby endangering the economic activities (e.g. ECO–tourism, hunting) that are derived from it. When attempting to control the disease and limit its effects, a lack of information and the need to make decisions quickly in a 'crisis' situation lead to the application of strategies that are not appropriate for the management of the disease. We believe that the management of diseases in wild animals generally requires solid scientific evidence grounded on corrective measures with potentially irremediable consequences for the future of the wild population. Short–term specific measures including pharmacological treatment and mass culls are too costly, too limited in duration and have little effect on overall population health. Given that it is difficult to predict where and when the next outbreak of sarcoptic mange will occur, further research is needed on the real effectiveness of the different management strategies of sarcoptic mange in field conditions, with proven results that may help wildlife managers in the decision–making process.

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