Veterinary Parasitology 163 (2009) 179–184

Contents lists available at ScienceDirect

Veterinary Parasitology

journal homepage: www.elsevier.com/locate/vetpar

Short communication

# Mange in alpacas, llamas and goats in the UK: Incidence and risk

J. Lusat *, E.R. Morgan, R. Wall

*Veterinary Parasitology & Ecology Group, School of Biological Sciences, University of Bristol, BS8 1UG, UK*

ARTICLE INFO

*Article history:*
Received 17 February 2009
Received in revised form 30 March 2009
Accepted 2 April 2009

*Keywords:*
Alpaca
Camelid
Llama
Goat
Importation
Mange
Disease risk

ABSTRACT

A retrospective postal questionnaire was used to obtain information about the prevalence of mange and its association with husbandry-related risk factors, in alpaca, llama and goat herds in the UK. In total 1797 questionnaires were sent out to members of the British Alpaca Society, the British Llama Society and the British Goat Society, giving response rates of 40.4%, 29.3% and 22.8% from the three groups, respectively. Between January and December 2007, mange was reported in 52.2% (151 of 292), 14% (9 of 66) and 21% (41 of 194) alpaca, llama and goat herds, respectively. However, these figures must be treated with some caution as only 37–51% of the farmers had their diagnosis of mange confirmed by a veterinarian or animal health laboratory. In herds where the causal agent was confirmed: psoroptic, sarcoptic, chorioptic and mixed infections were all reported, with chorioptic mange reported most frequently. Risk analysis showed that the prevalence of reported cases mange in alpacas was significantly associated with herd size and the country from which the animals were imported. Alpaca farmers who had larger herds were more likely to report mange and farmers who imported their animals from Peru were 1.5 times more likely to report mange than farmers who imported animals from elsewhere or who did not import. There was no significant confounding between these two risk factors. The results show that mange continues to be a major problem for camelids and goats in the UK, and suggests that inadequate control on farms and lack of control when in quarantine are two factors that contribute to ongoing problems with mange. However, given the relatively low contribution of imported animals to the national herd each year, it is likely that poor on-farm control may be of greatest importance.



## 1. Introduction

Camelid species have long been valued as a source of meat, milk, fibre, transport and labour, particularly in South America. Outside South America, alpaca and llama husbandry is growing, especially for fibre production and they have high commercial value as breeding animals (D'Alterio et al., 2006). In the UK, for example the total population of camelids increased from an estimated 699 herds in 1992/1993 (66% llama, 21% alpaca and 13% guanaco) to 3520 in 2000/2001 (77% alpaca and 20% llama) (Davis et al., 1998; D'Alterio et al., 2006). There are currently approximately 2000 llamas in the UK, while the number of alpacas now exceeds 15,000 registered animals, with probably another 5000 unregistered. Most of these herds are present in the south and south-west of England, although numbers are increasing in the north, Wales and Scotland (D'Alterio, 2006). Mixed species herds (i.e. alpaca/llama) are rare, and the majority of herds consist of fewer than 10 animals (D'Alterio et al., 2006).

Camelids are subject to a range of dermatological and parasitic problems, of which mange may be particularly severe, occasionally fatal and, in the case of sarcoptic mange, zoonotic (Rosychuk, 1989, 1994; Clauss et al., 2004; Foster et al., 2007; Lau et al., 2007; Twomey et al., 2009). Chronic infestation with *Sarcoptes*, *Chorioptes* and *Psoroptes* mites have all been observed in alpacas in the UK (D'Alterio et al., 2001, 2005; Foster et al., 2007) and in

* Corresponding author. Tel.: +44 117 928 9182.
*E-mail address:* jacqueline.lusat@bristol.ac.uk (J. Lusat).

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doi:10.1016/j.vetpar.2009.04.007

North America (Foreyt et al., 1992). Some animals may have concurrent infestations with *Chorioptes* and either *Psoroptes* or *Sarcoptes*, or even all three genera, although *Chorioptes* appear to be the most common (D'Alterio et al., 2005). Chorioptic mange in South American camelids is usually assumed to occur on the lower legs and belly and to involve *Chorioptes bovis* (Foster et al., 2007). *Psoroptes* collected from alpaca have been shown to be *P. ovis* (D'Alterio et al., 2001; Pegler et al., 2005) and are usually restricted to the ears where they may be responsible for head-shaking and incoordination, causing severe scaling and predominantly crusty lesions on the pinnae.

Goats share a number of diseases with other livestock, particularly with regard to parasitic infections (Taylor, 2002). There are currently about 90,000 goats in the UK flock amongst which mange may be particularly common and debilitating skin condition. However, while infestations may be caused by *Sarcoptes scabiei*, *Psoroptes* spp., *Chorioptes* spp. or *Demodex canis* var. *caprae*, chorioptic mange is the most common while other forms of mange are relatively rare (Smith, 1981; Matthews, 2009). Goats can be infested both with otodectic forms and body forms of mange; in the former case *Psoroptes* mites infest the ears, usually causing only mild clinical signs, although there may be occasional head shaking and scratching (Taylor, 2002). However, in severe infestations it can produce crusting, alopecia and excoriation of the pinnae, and pruritic otitis externa, sometimes leading to otitis media and severe vestibular diseases (Taylor, 2002).

The aim of the work described here was to use a retrospective postal questionnaire to obtain detailed information quantifying the prevalence of mange in alpacas, llama and goats in the UK and to use these data to consider husbandry factors associated with disease risk.

## 2. Materials and methods

### 2.1. Questionnaire design

Retrospective questionnaires were designed to obtain information relating to the period between January and December 2007. Two different sets of questionnaire were prepared targeting alpaca/llama and goat breeders. Given the busy target audience, the questionnaire was designed to be visually appealing and short, so that it could be completed easily and quickly. In both sets of questionnaires, questions were largely closed, with a small section for open comment. The design also aimed to maintain the respondent's compliance and interest by placing questions of high importance at the beginning of the questionnaire, and those used to check consistency of answers at the end.

A preliminary version of the questionnaire was trialled in November 2007 before the modified final sets were distributed. The final version was two pages in length, printed using black ink on pink-coloured paper, to enhance the visual appearance. With the questionnaire was included a cover letter explaining the aims of the survey and a pre-paid and addressed envelope. The first three questions asked whether the breeders had mange in their herd, followed with questions relating to the diagnosis and cause of the mange. The subsequent three questions enquired about the site of any lesions, the treatment given and the outcome, and the final eight questions asked about various aspects of the time of infection, ages and number of infected animal and the herd/flock size.

Given the lack of clarity in estimates of population size and the expected prevalence of mange in the three study populations, it proved difficult to calculate accurately the sample size required for adequate study power. Hence, in December 2007, 722 questionnaire were mailed directly to all members of the British Alpaca Society, and 225 and 850 questionnaires were distributed by the British Llama Society and British Goat Society respectively along with their bimonthly journal. This was expected to reach the entire membership of each of the three breed organizations.

### 2.2. Data management and analysis

Each questionnaire carried a unique code, which could be traced to an address for the alpaca breeders, since the questionnaires were sent directly. If respondents to the llama and goat questionnaires elected to remain anonymous, wherever possible the postmark on the return envelope was used to identify the general origin location. This proved effective and the region or origin was ascertained for 436 of the 552 completed questionnaires returned. The questionnaire data was entered into an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) and used to calculate summary statistics, then analysed using SPSS 15.0 (SPSS Inc., Chicago, IL, USA). The relationship between the presence or absence of mange and a range husbandry factors were tested using Nominal Logistic Regression in SPSS. All means are presented with 95% confidence intervals.

## 3. Results

### 3.1. Response rate

Of the 722, 225 and 850 questionnaires sent out, 321 of the questionnaires were returned by members of the British Alpaca Society (BAS), 67 from members of the British Llama Society (BLS) and 210 from members of the British Goat Society (BGS) by the cut-off date in February 2008. Amongst the returned questionnaires, 46 gave unusable or blank returns and so were not included in the analysis, leaving overall response rates of 40.4%, 29.3% and 22.8% for BAS, BLS and BGS members, respectively.

### 3.2. Mange prevalence

Of alpaca herds, 151 (52%) reported having mange; 9 llama herds (14%) and 41 goat herds (21%) also reported mange (Fig. 1). The rest reported no mange, or in some cases were unsure and in the latter case were classified for this analysis as not having mange. In terms of the numbers of individual animals infested, the probability of hosts having mange at any given time was estimated as the number of individuals with the disease at a particular time divided by number of individuals in the population at risk at that time (Thrusfield, 1995) which gave 0.089 (8.9%),

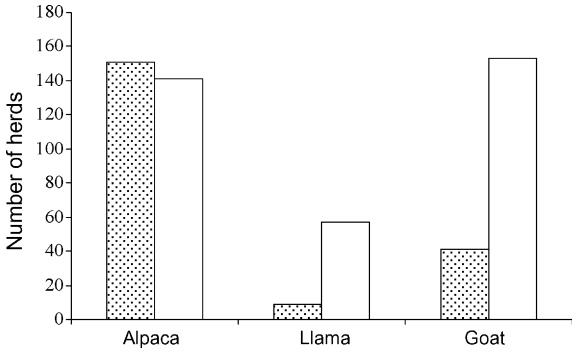


**Fig. 1.** The number of herds reporting mange or no mange between January and December 2007 in response to a retrospective postal questionnaire (closed bars = mange; open bars = no mange).

0.026 (2.6%) and 0.0176 (1.7%) for alpacas, llamas and goats respectively.

90.9% of the alpacas and 85.5% of llamas were maintained permanently on pasture with access to a shelter. For goats, 33.8% were kept on pasture, 26.9% indoors, 12.8% were winter housed and 26.5% kept in other housing.

In the alpaca herds that reported mange, 67% of the animals were more than 18 months old, 21.8% were 6–18 months old 15% were less than 6 months of age. For llama herds with mange, 80% of the animals were more than 18 months old. In goats herds with mange, 63.3% of the animals were more than 18 months old, 23.3% were 6–18 months and 13.3% were less than 6 months old. There was no significant difference in the prevalence of mange in males or females ($\chi^2 = 3.4$, $P > 0.05$) but for llamas and goats there was a greater prevalence of mange in females than males ($\chi^2 = 28.98$, $P < 0.001$; $\chi^2 = 562$, $P < 0.001$ respectively).

Most alpaca herds were in England (224) with relatively small numbers in Wales (11), Scotland (10) and Northern Ireland (3). For 44 herds it was not possible to determine the location from the questionnaire. The prevalence of mange was significantly higher in herds in England than elsewhere ($\chi^2 = 13.3$, $P > 0.001$); 57.6% of alpaca herds in England had mange compared with 32% for herds in other areas.

In England there were 38 llama herds, with only 6 in Wales, 1 in Northern Ireland and 3 in Scotland. The location of 18 llama herds could not be determined. Again, most goat herds were in England (114), with 14 in Wales, 3 in Northern Ireland, 9 in Scotland, and 54 not known. There were no regional differences in the prevalence of mange in either llama or goat herds in different areas.

Only half of the farmers who reported mange had had the diagnosis and aetiological agent confirmed by a veterinarian or animal health laboratory, with 48.5% of alpaca farmers and 63.1% of goat farmers diagnosing mange themselves. In alpaca herds in which the causal agent of the mange was reported as having been confirmed: 6 were diagnosed with psoroptic mange, 22 with chorioptic mange, and 18 sarcoptic, 5 herds had mixed infections of chorioptic and psoroptic mange, while 8 put "other" without further specification. The number of llama herds in which the type of mange was confirmed was too low to warrant analysis. Amongst the goats, where it was reported that diagnosis was confirmed, 10 were reported to be chorioptic, 1 psoroptic, and 3 sarcoptic, with no mixed infections and one "other".

Amongst infected alpaca herds, 146 herds treated their infected animals and 5 did not; 89 herds reported that the mange was cured, in 58 the mange persisted, 3 claimed that their infested alpacas died and in one herd the infected individual was euthanased. Again llama numbers are too low to permit analysis. For goats, treatment was given in 39 herds and no treatment in 2 herds. Of the treated cases, 29 were cured and 10 respondents reported that mange persisted. In alpacas, 36 herd owners reported that they had only one outbreak in the year, where an outbreak is defined as a continuous period of mange over time. More than one outbreak were reported by 103 respondents, where multiple outbreaks are defined as episodes of mange separated by at least one apparently mange-free month. For llamas and goats 2 herds of each reported only one outbreak in the year, and 4 and 191 herds multiple outbreaks, respectively.

### 3.3. Seasonal incidence

There was a significant difference in the incidence pattern of mange in alpaca and goat herds over time. The incidence of mange outbreaks in alpacas changed significantly over time and mange was reported more commonly during the summer months, peaking in July and August, and least commonly in November to January ($\chi^2 = 46.6$, d.f. = 11, $P < 0.001$). In goats, however, the pattern did not vary significantly over the year ($\chi^2 = 12.8$, d.f. = 11, $P > 0.05$), although the underlying trend was for incidence to be highest in winter, but with a very large degree of variance (Fig. 2). The number of llama herds reporting mange was too low to allow similar analysis.

### 3.4. Risk factors and analysis

Presence or absence of reported mange within alpaca and goats herds was entered into a nominal logistic regression as the dependent variable with the risk factors

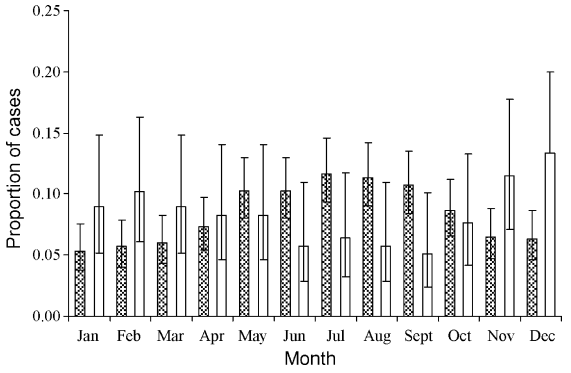


**Fig. 2.** The proportion of mange cases reported each month between January and December 2007 for alpacas (solid bars) and goats (open bars). Brackets represent 95% exact binomial confidence intervals.

discussed below as independent factors. The analysis was not carried out for llama herds because of the very low numbers positive for mange.

*3.4.1. Herd size*

The median size of alpaca, llama and goat herds, between January and December 2007, were 12 (range = 1–800), 5 (range = 1–64) and 9 (range = 1–2320) animals, respectively. Median sizes for alpaca herds in South West, South East, Central and North regions were 11, 9.5, 12 and 18 respectively. Alpaca herds found elsewhere had a median size of 14 animals and respondents who did not provide their address had a median herd size of 13.5 animals. For the analysis herd size was categorised as 1–10, 11–20, 21–40 and more than 40 animals per herd (Fig. 3a).

*3.4.2. Co-grazing*

Co-grazing was reported in all host populations; 21.6%, 7.6% and 6.7% of alpaca, llama and goat herds reported their animals were co-grazed with other livestock. Sheep (37 herds), goats (8 herds), cattle (21 herds), pigs (2 herds) and other animals (15 herds) were reported co-graze with alpacas; 2 farmers reported their llamas to co-graze with sheep, 2 herds with goats, one with cattle and 3 herds with other animals. 7 goat herds co-grazed with sheep, 5 with cattle, 3 with pigs, 2 with alpacas/llamas and 4 with other animals. For regression analysis, grazing management was entered as co-grazed or not co-grazed.

*3.4.3. Importation*

Of the 292 alpaca herds, 67 (22.9%) herds imported alpacas and 225 (77.1%) did not import. Of the 67 herds importing alpacas; 70.1% reported mange and 29.9% no mange (Fig. 3). Of the 66 llama herds, one herd (1.5%) imported animals and 65 herds (98.5%) did not import. No mange was reported from the imported herd group; 13.8% of those not importing reported mange. Importation was entered as not practised or, if practised, by country of origin.

*3.4.4. Region*

Region was entered as Northern England, Central England, South East England, South West England, combined Wales, Scotland and Northern Ireland, or no region reported.

*3.4.5. Risk analysis*

The analysis showed that the prevalence of mange in alpacas was significantly associated with the herd size and importation (Hosmer and Lemeshow, $\chi^2 = 10.01$, d.f. = 5, $P = 0.075$). However, there was a considerable level of unexplained variation (Nagelkerke $R^2 = 0.149$).

Farmers who had larger herds were significantly more likely to report mange; in herds with more than 40 animals, 74.4% reported mange; in herds of between 21 and 40 animals, 60.8% reported mange, in herds of 11–20 animals, 50.7% reported mange and in herds of 1–10 animals 42.2% reported mange (Fig. 3b). The prevalence of mange in alpacas was also significantly associated with importation and the countries from which the animals were imported. Odds ratios showed that farmers who imported their alpacas from Peru were 1.5 times more likely to report mange; 95.2% of alpaca herds into which animals were imported from Peru reported mange, compared with 51.7% of herds that imported animals from Chile, 64.3% of herds that imported animals from elsewhere such as Australia, Canada, New Zealand, and USA, and 46.9% of herds that did not import (Fig. 4).

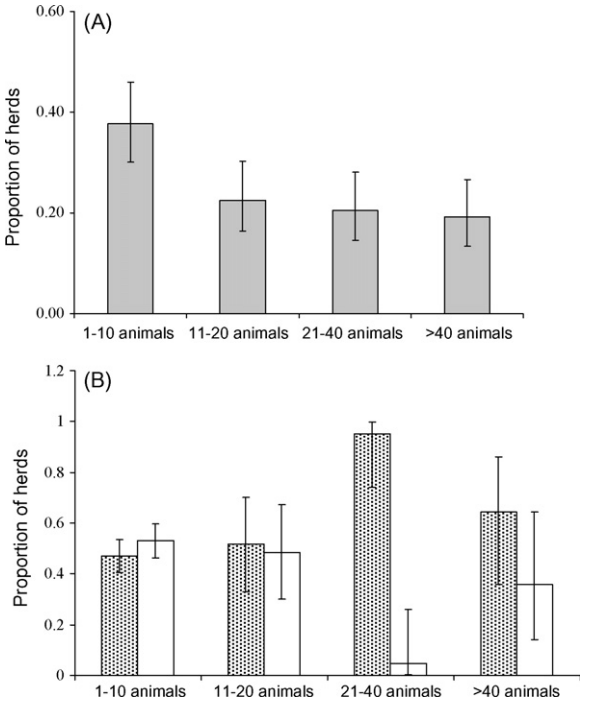


**Fig. 3.** (a) The frequency of alpaca herd size classes and (b) the proportion (±95% confidence intervals) of herds within each herd-size class which reported (closed bars) or did not report (open bars) mange between January and December 2007.

No other factors were significantly associated with mange prevalence. Comparison of the number of herds with mange in the various herd size classes showed that there was no significant difference in the number which imported animals ($\chi^2 = 2.78$, d.f. = 2, $P > 0.1$) and hence it

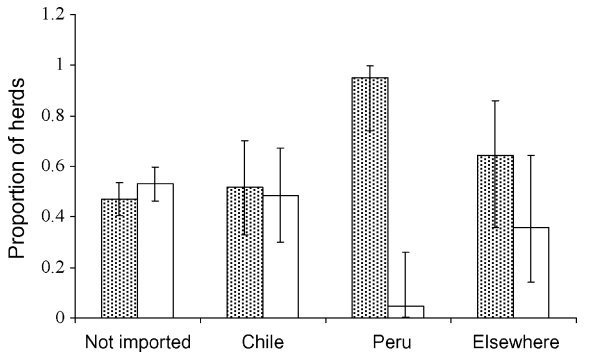


**Fig. 4.** The proportion (±95% exact binomial confidence intervals) of alpaca herds that did not import animals, or imported from Chile, Peru, or elsewhere, and which also reported (closed bars) or did not report (open bars) mange between January and December 2007.

appears that there is no confounding between herd size and whether animals are likely to have been imported.

There were no significant associations between any of the risk factors and the presence or absence of mange in goats.

## 4. Discussion

The present study used a cross-sectional postal questionnaire approach to obtain data about mange in alpacas, llamas and goats in the UK. Postal questionnaires are a valuable means of obtaining prevalence data, being less expensive than in-person interviews, more rapidly completed, and allowing respondents time to collect the requested information (O'Toole et al., 1986). However, their major disadvantage is the lower response rates that they generate (Dillman et al., 1993). Mange in camelids has been the subject of a number of recent surveys in the UK (Davis et al., 1998; Wright et al., 1998; D'Alterio et al., 2006). In previous studies, postal questionnaires sent to camelid owners achieved response rates of 59% (84 of 142; Davies et al., 1998) and 32.3% (225 of 696; D'Alterio et al., 2006). The present study was considerably larger than either of the previous surveys and obtained a high response rate with alpaca owners (40.4%), to whom the questionnaires were mailed directly, but poorer response rates when the questionnaires were mailed as an inclusion with other society literature (29.3% and 22.8% llama and goat owners respectively). Clearly, response rate is highly sensitive to the method through which questionnaires are delivered to farmers.

Dermatological conditions in camelids associated with chronic infestation with mites have long been recognised as major problems in their husbandry (Foster et al., 2007). *Sarcoptes*, *Chorioptes* and *Psoroptes* mites have all been observed in alpacas in the UK (Bates et al., 2001). In a study of 9 alpaca herds in 2001/2002, eight of which had reported skin problems, all animals with skin disease plus one in five randomly selected in-contact healthy individuals were given a detailed clinical examination (D'Alterio et al., 2005). Amongst these animals 33 (39.8%) were positive for *Chorioptes* spp. mites. While this study is of interest in confirming the presence of chorioptic mange in alpaca herds, because herds were chosen on the basis of existing skin problems and because of the sampling strategy within herds, the prevalence data reported cannot be generalised. However, in a subsequent postal questionnaire survey of camelid owners, ectoparasites were reported as the presumptive cause of skin disease by 26.4% by the owners (D'Alterio et al., 2006).

Here, more mange was reported in alpacas (52%) than in llamas (14%). Some caution must be used when interpreting these headline prevalence figures, however, as only half of the farmers had had their mange diagnosed by a veterinarian or animal health laboratory, with 48.5% of alpaca farmers diagnosing mange themselves. Amongst the confirmed diagnoses, most cases of mange were chorioptic or sarcoptic, with relatively few cases of psoroptic mange. This accords with the work of D'Alterio et al. (2005) who found only four out of 36 examined animals to be infected with *Psoroptes* mites. *Psoroptes* spp. mites are largely, though not exclusively, associated with the ear canal in alpacas (Bates et al., 2001) whereas *Chorioptes* and *Sarcoptes* are usually associated with body mange. Some concern has been expressed previously that goats and camelids may act as reservoirs of *Psoroptes* mites, which might be transmissible to sheep, thereby circumventing attempts to eradicate scab through sheep treatment. The results of this study suggest that the prevalence of psoroptic mange in these species is so low that they are unlikely to form a significant epidemiological risk to the sheep population.

In alpaca herds, outbreaks were most common during the summer months. Risk analysis shows that the prevalence of mange in alpacas was significantly associated with herd size and the country from which the animals were imported. The number of llama herds reporting mange was too low to allow similar meaningful analysis. Alpaca farmers who had larger herds were more likely to report mange. In addition, alpaca farmers who imported their animals from Peru were 1.5 times more likely to report mange. Since only 23% of alpaca herds reported importing animals during the study year, the relatively low contribution of imported animals to the national herd each year may suggest that poor on-farm control may be of greatest importance to the endemic status of mange. Nevertheless, even low levels of imported infection may be epidemiologically significant in maintaining the UK populations of mange mites.

Mange in goats is also common worldwide (Jackson, 1986; Friel and Greiner, 1988; Nooruddin and Mondal, 1996) but has been little studied in the UK. *Chorioptes* mites are particularly common in goats, with infestations usually subclinical (Cremers, 1985). In a study of goats in Malaysia *Chorioptes texanus* was found in 20.7%, *Psoroptes* spp. in 19.3%, *S. scabiei* in 18.6% and *Demodex canis* var. *caprae* in 0.4% of samples taken from skin lesions. Infestation by *Chorioptes* was mostly observed on farms with poor management and nutrition (Dorny et al., 1994). *Psoroptes* spp. are again predominantly associated with the ear canal (Munro and Munro, 1980; Friel and Greiner, 1988) causing otitis, irritation, head shaking and scratching (Williams and Williams, 1978). Sarcoptic mange appears to be the most unpleasant and difficult to treat of all the mange infestations in goats (Jackson, 1986). In the present study, mange was reported in 21% of the goat herds surveyed, with most of the confirmed cases diagnosed as chorioptic. No significant associations could be detected between the risk factors considered and the prevalence of mange. The problem appeared to be most common in the winter, though with high degree of variation around this trend. The treatment of *Chorioptes* in dairy goats is problematic since the need to avoid milk residues may severely constrain treatment options.

Of particular importance is the finding that attempts to treat mange are clearly inadequate. Of the infected alpaca herds which treated animals, 89 reported that the mange was cured while in 58 the mange persisted. In alpacas, 36 herds reported only one outbreak in the year while 103 reported multiple outbreaks over the year. In goats, after treatment 29 outbreaks were cured while 10

persisted, and 2 herds reported a single outbreak in the year compared with 191 herds reporting multiple outbreaks. The primary approach to the treatment of mange in these animals is with injectable macrocyclic lactones (e.g. Zamri-Saad et al., 1990; Twomey et al., 2009), usually accompanied by the external application of a suitable emollient to lesions (ranging from udder cream to a range of vegetable or petroleum derived oils). However, the failure rate suggest that many farmers use pharmaceutical products inappropriately, possibly treating only clinically apparent infections, failing to quarantine infected animals, or separate treated from untreated individuals. This is probably exacerbated by widespread movement of animals between shows and to stud. Evidently, as this study shows, for alpacas at least, failings in the management of mange are also compounded by inadequate treatment and quarantine of imported stock. Mange is such a widespread problem with such significant welfare issues, that a major and urgent education campaign about appropriate management is warranted, as well as further research into effective treatment and prevention at the individual, herd and between-herd levels.

## Conflict of interest statement

The authors have no any financial or personal relationships with people or organisations that could have inappropriately influenced this work.

## Acknowledgements

The British Camelids Association, BAS, BLA and BGS are kindly acknowledged for assistance with sending the questionnaire. We are also grateful to the University of Bristol, Ministry of Higher Education Malaysia, Universiti Putra Malaysia (UPM) and colleagues in the Veterinary Parasitology and Ecology group.

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