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EXPERIMENTAL MANGE INFECTION IN CAMELS (*Camelus dromedarius*)

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ABSTRACT

This paper describes the experimental introduction of a mange-infected camel into a clean herd, with subsequent observations of the resulting effects on the herd. Twelve days after the introduction, 2 camels developed pruritus, followed by alopecia with papule development. One week later all four trial camels had contracted mange. The four camel caretakers developed pseudo-scabies two days following exposure, which required therapy. Due to the recurrence of clinical symptoms, it was necessary to repeat treatment on several occasions. All four trial animals had to be treated with ivermectin injections. However, mange reappeared and only an intensive treatment regimen eradicated the disease. This regimen included ivermectin- injection, ivermectin-bolus, spraying of camels and pens and movement to other pens. A second herd became infected five months after introduction of the mangy camel and had to undergo the same treatment regimen to eradicate the disease.

Mites were only found in skin biopsies in the two out of four experimentally infected and pruritic camels. However, in the chronically infected mangy herd from which the infected camel originated, eleven out of fifteen cases were confirmed.

Key words: *Camelus dromedarius*, contact transmission/infection, pseudoscabies, sarcoptic mange, *Sarcoptes scabiei,* treatment

Sarcoptic mange is regarded as one of the most prevalent and serious camel diseases (Lodha, 1966; Higgins, 1983). It is often ranked second in importance to trypanosomosis in dromedary disorders (Pegram and Higgins, 1992). Any camelid, regardless of sex and age, may be affected by *Sarcoptes (S.) scabiei* (Nayel and Abu-Samra, 1986c). However, some reports state that the infection is more prevalent in younger animals (Rathore and Lodha, 1973) and in animals in poor condition (Lodha, 1966; Higgins, 1983, 1984). Conflicting reports exist in the literature with regard to the time of year when disease incidence is highest. Some authors describe a quiescent phase, usually coinciding with winter (Pegram and Higgins, 1992). Consistent with this, a higher incidence has been observed in Saudi Arabia during the summer months (Higgins, 1984). However, others describe a higher incidence in winter (Lodha, 1966; Rathore and Lodha, 1973; Nayel and Abu-Samra, 1986c).

Sarcoptic mites can survive outside their host for several days and remain infective if the microclimate is sufficiently moist and cool (Arlian, 1989; Nayel and Abu-Samra, 1986a). *S. scabiei* isolated from naturally infected sheep and goats have been successfully transferred to dromedaries (Nayel and Abu-Samra, 1986a, b) and transmission of *S. scabiei* from camels to sheep and horses have also been reported (Mellanby, 1946; Alvarado *et al*, 1966). Sarcoptic mange has been confirmed in 10 orders, 27 families and 104 species of domestic, free-ranging and wild mammals (Bornstein *et al*, 2001) and can seriously affect populations of CITES-listed species (Pence and Ueckermann, 2002), for example the highly endangered chamois and Iberian Ibex (Fernandez-Moran *et al*, 1997; Rossi *et al*, 1995).

The probability of finding *S. scabiei* in infected dogs, even when applying multiple skin scrapings, is less than 50% (Hill and Steinberg, 1993) and a similar low recovery exists in infected camels (Higgins, 1984). Acute lesions are often suggestive of *S. scabiei* infection due to hypersensitivity reactions seen in histological skin samples. In sarcoptic mange of humans and pigs

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(Davies and Moon, 1990) it has been shown, that lesions most probably result from hypersensitivity reactions. Therefore the presence of only a few burrowing sarcoptic mites may provoke a generalised hypersensitivity reaction leading to the typical acute signs of mange in the host. However, these findings alone are not conclusive because other parasites may cause similar skin lesions (Lodha, 1966; Abu-Samra and Imbabi, 1981). In mange, varying degrees of superficial dermatitis, epidermal spongiosis, hyperplasia and para- and hyperkeratosis may be observed. Eosinophils and mast cells are sometimes intermingled with neutrophils and macrophages.

To verify suspected cases, the mite must be demonstrated and that can prove difficult. The development of an indirect ELISA, demonstrating specific antibodies to *S. scabiei* has markedly improved the diagnosis of sarcoptic mange in some animal species, e.g. dogs and pigs (Bornstein *et al*, 1995,1996; Bornstein and Wallgren, 1997). In dogs and swine this test has increased the probability of achieving a correct diagnosis from 30-50% to 95-98%. A similar ELISA has been developed for camels, but it has not yet been evaluated in the field (Bornstein *et al*, 1997).

Humans occasionally become infected with *S. scabiei* from a variety of species including camel, horse, pig, goat, sheep, chamois, ferret, fox, llama and alpaca (Leese, 1927; Alvarado *et al*, 1966; Fain, 1978; Schillinger, 1987; Raisinghani and Kumar, 1991; Basu *et al*, 1996). Direct transmission from camels to humans is most likely during milking, riding, and general handling (Basu *et al*, 1996).

The condition in humans is called scabies. However, cross-infections of *S. scabiei* from animals to humans are referred to as pseudo-scabies. Humans infected by the itch mite *S. scabiei* from camels, exhibit similar signs to those of classical scabies, namely pronounced intensive pruritus during the night. Erythema and papule formation are mainly seen in the inter-digital spaces of the hands, the flexor surface of the wrists, the forearms (Basu *et al*, 1996), elbows and axillary folds of milkers and between the thighs of riders. Scabies is usually self-limiting with symptoms gradually waning and disappearing within two weeks following interruption of contact with infected animals.

The aim of this study was firstly to evaluate the infectivity of mange in a small herd of dromedaries, and secondly to investigate the sequence of signs and the recovery of *S. scabiei*.

Materials and Methods

Experimental infection

Four dromedaries (herd 1: 43, 44, 46, 53; Table 1) in Dubai, United Arab Emirates, were exposed to an adult female camel (4) that was naturally severely infected with *S. scabiei*. This camel was selected from a herd containing 25 camels (herd 3), all showing severe sarcoptic mange. Three control camels (herd 2: 42, Old, Black) were kept in an enclosure separate from herd 1, but at a distance of 10 m and herded by the same persons. Ten days following its introduction into herd 1, the naturally infected camel (4) was euthanised on humane grounds due to untreatable severe mange.

Table 1. Overview of the infection trial.

Mangy herd 3	Introduced mangy camel	Experimental herd 1	Control herd 2
15 adults 10 calves	Camel 4	Camel 43, 44, 46 and 53	Camel 42, Old and Black

Sampling and testing procedures

All trial camels (herds 1 and 2) were inspected daily. Deep skin scrapings were taken before and 3 weeks and 5 months after introduction of the mangy camel into this herd. The samples were suspended in a 10% solution of KOH in a water-bath at 37°C for a few hours and then centrifuged at 3000 rpm for 3 min. The supernatant was decanted and one to two drops of glycerine were added to the sediment, which was examined microscopically for the presence of ectoparasites, in particular *S. scabiei*.

Skin biopsies were taken from lesions of all trial camels by sterile disposable 8 mm skin biopsy punchers (Jørgen Kruuse A/S) 6 weeks after introduction of the mangy camel (Table 2). The skin biopsies were fixed in neutral 10% buffered formalin, pH 7.4 and processed for routine

histology. After paraffin embedding, 4µm thick sections were cut and stained with haematoxylin and eosin (H and E), periodic acid Schiff (PAS) and Grocott´s methenamine silver (GMS) for fungi.

Treatment

Twenty-four days following exposure to the mangy camel 4, the 4 camels in herd 1 were treated with ivermectin (Ivomec®, MSD AGVET) at a dose rate of 1 ml per 50 kg body weight (200 g/kg) subcutaneously, followed by a second injection three weeks later.

Due to the recurrence of signs four months later in herd 1 and the simultaneous appearance of clinical signs even in the control animals of herd 2, all camels were (beside the repeated ivermectin injections) also treated with orally administered ivermectin-boluses (Ivomec®, SR Bolus, Merial, 1.72 g ivermectin/bolus). They were also sprayed four times at weekly intervals with Triple Squad Super® (alphacypermethrin 5% w/vol; cypermethrin 10% w/vol; piperonyl butroxide 10% w/vol; FLD Chemicals Ltd. Chessington, UK; 20 ml in 10 l water). Furthermore, following each application of the spray, they were moved to another pen and the ground of the vacated pens were also sprayed with Triple Squad Super®.

Camel handlers were treated daily with dermal Jacutin® emulsion (lindane 0.3 g) or Prioderm® (malathion 0.5 % w/v) for 3 consecutive days and Stromectol® 6 mg (ivermectin) orally.

Results

Epidemiology

The first signs of pruritus in herd 1 appeared in camels 43 and 44, twelve days following introduction of the mangy camel no. 4. Two days later, alopecia with papules was seen on the left hind leg of camel 44 and on the head (Fig 1) and the inguinal area of camel 43. During the following week, alopecia, papule formation, and crusts with pruritus and a moth-eaten appearance were evident on all the exposed camels. All (4) people who came in close contact with the infected camels of herd 1 developed pseudo-scabies two days following initial exposure and required treatment.

Due to the presence of untreatable severe mange (Fig 2), the naturally infected camel 4 was euthanised on humane grounds. Following treatment of herd 1 (twenty four days after introduction of the mangy camel), the pruritus was the first clinical sign to disappear, followed one month later by healing of the skin lesions. Hair regrowth was not complete for a further two to three months. Also, within three months post-treatment, the other mange associated lesions (papules, partial and localised alopecia with localised, small-circumscribed hyperkeratotic areas) gradually disappeared. No skin lesions or any other abnormal clinical features were observed in herd 2 during this period.

However, one month later (five months after introduction of the mangy camel no. 4), pruritus reappeared in herd 1 and simultaneously appeared for the first time in herd 2. It took two months to eradicate the disease through intensive treatment (ivermectin- injection, ivermectin-bolus, spraying of camels and weekly spraying of pens) and herd management (movement).

Skin scrapings

S. scabiei were found in skin scrapings in 11 out of 15 investigated dromedaries from the naturally infected herd 3 and in camel no. 4 (Table 2). In most cases, typical eggs of the mites were also seen. No mites were seen in herd 1 and 2 before introduction of the mangy camel. Two camels of herd 1 became mite positive 3 weeks after the introduction of the mangy camel. No mites were found in the other two dromedaries of the experimental herd 1 and none in the control herd 2. However, two camels of herd 1 and 2 became parasitologically positive again 4 months later.

Skin biopsies

Severe hyperkeratotic dermatitis was found in skin biopsies taken from the mangy camel before and ten days after introduction into herd 1. Adult *S. scabiei* mites (Fig 3), nymphs, larvae and eggs were demonstrated by histopathological investigation.

No mites were detected in skin biopsies from herd 1 and 2, taken six weeks after introduction of the mangy camel. However, in all four camels of herd 1, histology revealed varying degrees of superficial dermatitis, epidermal spongiosis, hyperplasia and parakeratotic hyperkeratosis. Eosinophils and mast cells infiltrated the

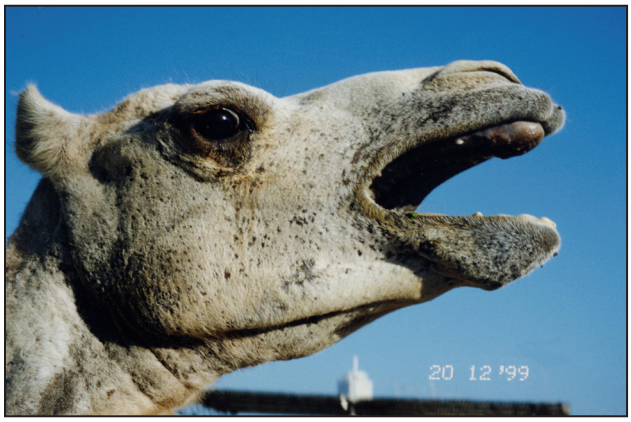

Fig 1. First signs of camel mange (small spots of alopecia with papules) on the head of camel 43.

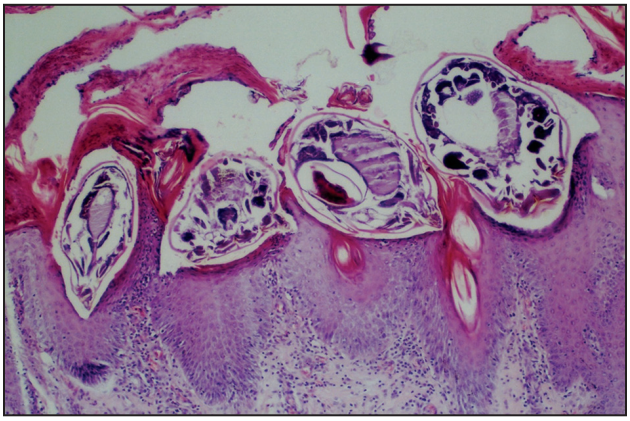

Fig 3. Adult *S.scabiei* mites and severe hyperkeratotic dermatitis in skin biopsy from camel no. 4 (HE stain).

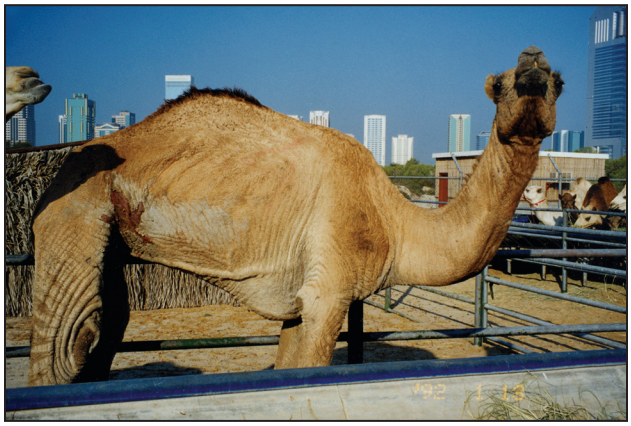

Fig 2. The introduced naturally infected camel no. 4 showing severe chronic mange.

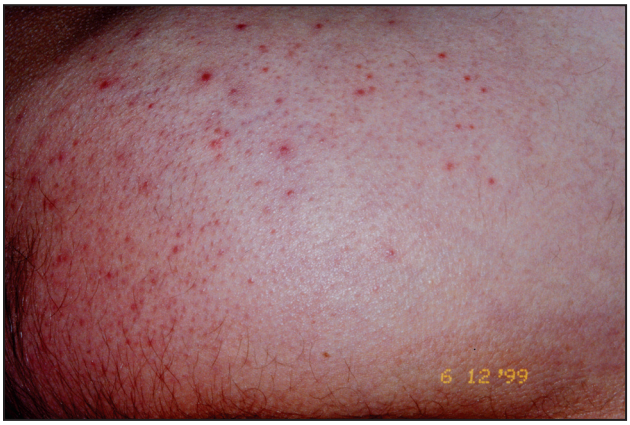

Fig 4. Pseudo-scabies with erythema papules on a human leg caused by *S. scabiei*.

epidermis together with neutrophils and macrophages, suggestive of *S. scabiei* infection. No fungus was seen in any sample.

Treatment

Because of repeated occurrence of pseudo-scabies in all people who came in close contact with the infected camels of herd 1, treatment of camels was started twenty-four days after the four dromedaries of herd 1 were exposed to the mangy camel no. 4. Two injections of ivermectin within three weeks at the recommended dosage (Ivomec®, MSD AGVET, Holland, 1 ml=10g ivermectin per 50 kg body weight) reduced the clinical signs over a 3-month period, but did not eradicate the disease. The signs reappeared 5 months after introduction of the mangy camel in herd 1 and appeared at the same time also in herd 2.

Intensive treatment (ivermectin injection, ivermectin bolus, spraying of camels and weekly spraying of pens) had to be carried out to eradicate the disease two months later. Pseudo-scabies lesions of the camel handlers receded within three days due to treatment.

Discussion

In the present experiment we attempted to simulate a natural infection by introducing a

Table 2. Results of sampling.

Herd/camels	Mites in skin scrapings			Mites in skin biopsies
	Before introduction of camel 4	3 weeks after introduction	5 months after introduction	6 weeks after introduction
Herd 1 4 camels	4 x neg.	2 x ++ 2 x neg.	2 x ++ 2 x neg.	4 x neg.
Herd 2 3 camels	3 x neg.	3 x neg.	2 x ++ 1 x neg.	3 x neg.
Herd 3 15 camels tested	11 x +++ 4 x neg.			

neg. = no mites found ++ = several mites +++ = numerous mites

naturally infected camel to a group of uninfected animals. This goal was achieved, as not only the camels but also the camel keepers became infected.

The first signs of mange in camels are small hyperaemic papules often appearing on the medial aspect of the thighs or inguinal region, the head and neck, medial areas of the flanks, udder, and shoulder (Wernery and Kaaden, 2002). In severe cases any part of the body may be affected. Most authors report that the humps and dorsal aspects of the neck are usually free of any signs of mange (Lodha, 1966; Rathore and Lodha, 1973; Higgins, 1983, 1984). However, Nayel and Abu-Samra (1986a, b, c) found mangy lesions on the dorsum (including the hump), both in naturally and experimentally infected camels. In our cases alopecia with papules was seen on the left hind leg of camel 44 and in the inguinal area of camel 43 two weeks after experimental infection. In the following week typical signs of mange, alopecia, papule formation, and crusts with pruritus and a moth-eaten appearance were evident on all four exposed camels. These lesions were accompanied by intense pruritus with excoriation and secondary infections. The self-induced trauma resulting from the pruritus contributed markedly to the alopecia.

The lesions spread and aggravate excoriation, alopecia, and crusting, resulting in more scabs. The latter may be rubbed away revealing a "red raw surface", erosions and wounds. Localised or generalised acute exudative dermatitis develops. Within a few weeks, the acute disease may develop to the chronic stage, which was the stage encountered in the mangy herd 3. Hyperkeratosis and proliferation of the dermis leads to the skin becoming thicker, fissured, and corrugated, appearing like a dried cracked field of clay (Wernery and Kaaden, 2002). Camels with generalised mange may eventually die from extreme wasting caused by the reduction in normal feed intake due to intense irritation and pruritus (Abu-Samra and Imbabi, 1981). This was also the case in camel 4, which had to be euthanised ten days after introduction into the new herd.

The incubation period is believed to be around 2 to 3 weeks (Lodha, 1966; Higgins, 1983). In our experiment it was twelve days, because the first signs of pruritus were observed twelve days after the mangy camel was introduced. However, mites were found only in two out of four experimentally infected and pruritic camels. The difficulties of finding the mites in the early stage of disease is known from *S. scabiei* infected dogs, with less than 50% success rate (Hill and Steinberg, 1993). This is described also for camels (Higgins, 1984) and reconfirmed with our results. In acute infections, mites are rarely found (Lodha, 1966), however in severe and long-standing chronic cases exhibiting severe hyperkeratosis in several host species, *S. scabiei* mites are found in the thousands. In such cases, the mites are observed in the hyperkeratotic and in the upper cell layers of the epithelium as in the crusty hyperkeratotic or "Norwegian" scabies in humans (Bornstein *et al*, 2001).

Higgins (1984) stressed the importance of taking proper and adequate numbers of skin scrapings from the individual mangy animal. Care should be taken to scrape at least 1 cm^2 area of the mangy skin. In chronic lesions where the skin is thickened and corrugated, scrapings should be made in the "valley" areas (Higgins, 1984). The scrapings should be done by parallel strokes of a sharp scalpel blade at the margins of the mange lesions. This is to be followed by taking deeper scrapings until capillary oozing occurs on the whole scraped surface. All scrapings, keratinous and epidermal material are collected and placed into a broad mouthed centrifuge tube. At least 3 to 4 scrapings should be taken per animal. From our experience there was no difficulty in the confirmation of chronic cases of mange, since numerous mites were found in thickened skin. In 11 out of 15 cases from herd 3, the mites were confirmed, despite obtaining only one skin scraping per camel.

Care has to be taken during handling and treatment of mangy camels, since the disease has a zoonotic potential. One of the authors accidentally became infested with *S. scabiei* when a mangy camel was walked for six hours to a different location. Twenty-four hours following contact, red spots were detected on the right forearm. It is believed that the mites may have crawled along the lead rope onto the arm. Eight days later severe erythema and papules were observed on both legs (Fig 4) and both arms with severe itching. There were no lesions on the head and very few papules on the body. Skin scrapings were taken from the leg and *S. scabiei* identified. After treatment with Jacutin® emulsion (lindane 0.3 g) or Prioderm® (malathion 0.5% w/v) for 3 consecutive days and Stromectol® 6 mg (ivermectin) orally, the lesions receded within 72 hours. All camel handlers also developed pseudo-scabies on the hands and arms two days after exposition, which required treatment. Due to repeated recurrence of pseudo-scabies, treatment of the camels was started at an early stage of the disease. Basu *et al* (1996) also described erythema and papule formation mainly in the interdigital spaces of the hands, the flexor surface of the wrists, the forearms, elbows and axillary folds of milkers and between the thighs of riders.

Sarcoptic mange has been described as a seasonal disease, which was particularly severe in winter months both in Bactrian camels in Mongolia and dromedaries in India (Higgins, 1986). In Saudi Arabia, Higgins (1984) on the other hand, found a higher prevalence during the hot summer months. In our study, which was carried out during the hot and humid summer months, mange was very severe.

The histopathological changes found in the infected animals were in agreement with earlier descriptions (Lodha, 1966; Nayel and Abu-Samra, 1986a). The epidermal changes of hyperplasia, acanthosis and hyperkeratosis are regular findings in sarcoptic mange in most host species as well as the non-specific inflammatory subepidermal and dermal changes (Bornstein *et al*, 2001). Some of these lesions are also seen in hypersensitivity reactions such as the presence of numerous eosinophils in the cellular exudate together with perivascular cuffing of predominantly lymphocytes and plasma cells. Immune mechanisms (adaptive immune system) are thought to be involved in the genesis of the clinical signs, i.e. the manifestation of the disease described in man (Dahl, 1983; Van Neste, 1987) and in pigs (Sheahan, 1975; Davis and Moon, 1990).

Ivermectin therapy has been shown to be effective and safe in camelids and cattle employing the same dose and regimen (Boyce *et al*, 1984; Raisinghani *et al*, 1989; Kumar and Yadav, 1993; Kuntze and Kuntze, 1991; Oukessou *et al*, 1996). The recommended dose is 200 µg/kg given subcutaneously and repeated after 15 days. The subcutaneous injection may be painful to camelids and some diffuse swelling at the injection site may appear after 24h (Wernery and Kaaden, 2002). During the injection procedure, camelids need to be well restrained in the crouched position.

In general, healing of scabies lesions following treatment is gradual. Pruritus ceases 7 to 10 days following the second injection. Four weeks after the second injection all previously alopectic areas are covered with growing hair (Hashim and Wasfi, 1986; Raisinghani *et al*, 1989), and complete healing of skin lesions occurs 145 days following first ivermectin injection (Raisinghani *et al*, 1989).

In our cases however, this treatment protocol (ivermectin injection, only) was not successful in eradication of the disease.

A combination of topical and injectible treatments (Ivermectin- injection, Ivermectin-bolus, spraying of camels and pens) as well as herd management (movement) was necessary for complete cure of the disease. This might be due to the fact that we were dealing with a pathogenic strain of *S. scabiei*, since no human infection was observed in a similar experiment in Kenya (Bornstein 2002, personal communication).

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Haematological and clinical biochemistry findings in captive juvenile guanacos (Lama guanicoe Müller 1776) in central Chile

The purpose of this study was to describe haematological and blood biochemistry findings of farmed guanacos in central Chile, in order to establish reference values for this species in captivity. Haematological ansd clinical biochemical measurements were performed on blood and plasma respectively, from 40 clinically healthy guanacos (20 females and 20 castrated males), aged between 2 and 3 years. The effects of gender and seasons of the year were studied. Gender affected the number of lymphocytes and the ratio of neutrophils:lymphocytes (N/L), with castrated males having a lower number of lymphocytes and higher N/L ratio than females. Seasons of the year affected most variables, presenting greater packed cell volume (PCV), haemoglobin (Hb), total protein (TP) and albumin values in winter than the rest of the seasons. White blood cells (WBCs) were not affected by season. Glucose decreased significantly over the year and creatine kinase (CK) activity, like glucose, had a tendency to decrease over the year, which may be related to habituation to sampling and handling. Haematological and clinical biochemistry values given in this study can serve as reference values for juvenile farmed guanacos in central Chile.

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