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(*Camelus bactrianus*)

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USE OF HYPOSENSITIZATION INJECTIONS TO CONTROL SEASONAL PRURITUS IN A BACTRIAN CAMEL (*CAMELUS BACTRIANUS*)

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Abstract: A 9-yr-old, female Bactrian camel (*Camelus bactrianus*) developed severe pruritus in June 1993. During the next 8 yr, the camel exhibited annual episodes of pruritus and epiphora, generally beginning in June and subsiding in October of each year. These signs could usually be controlled with topical agents and fly repellents, although pruritus flare-ups were effectively controlled with intermittent injections of diphenhydramine and corticosteroids. There were no signs during the colder months. The pruritus became more severe and difficult to control when the camel reached its 18th year. Histopathologic descriptions of skin biopsies taken from several sites suggested a hypersensitivity reaction with secondary changes because of bacterial infection or corticosteroid administration (or both). An intradermal test (IDT) performed using 62 allergens regionalized to Northern California resulted in 17 positive test sites. Hyposensitization therapy was initiated using allergens chosen on the basis of exposure, availability, and the results of the IDT, using standard protocols. The clinical signs of pruritus were markedly reduced in the 2 yr after the hyposensitization injections were initiated.

Key words: Atopic dermatitis, bactrian camel, *Camelus bactrianus*, hyposensitization, pruritus.

INTRODUCTION

Atopic dermatitis is a genetically programmed inflammatory and pruritic allergic skin disease in which the patient becomes hypersensitive to normally innocuous environmental allergens.¹⁶ It has been typified best in dogs,^{10,16,17} but similar entities have been described in cats^{8,12} and horses.^{4,5} Steroid-responsive pruritic dermatoses of suspect allergic origin have been reported for llamas (*Llama glama*).¹³ This report describes a case of atopic dermatitis in a Bactrian camel (*Camelus bactrianus*) where the use of intradermal testing resulted in successful hyposensitization therapy.

CASE REPORT

A 9-yr-old, female Bactrian camel housed with several unaffected camels for more than 7 yr at a wildlife park in northern California developed severe pruritus in early June 1993. The camels were maintained on a standard deworming protocol based on routine biannual fecal examinations; significant parasite loads were never identified. After

the pruritus began, the camel was housed in two different locations at the facility, a large open exhibit area and a series of connected smaller corrals with attached spacious three-sided stalls. The animal was frequently walked around the wildlife park but did not travel from the premises.

Hematology and serum enzyme panels were non-remarkable. No dermatophytes were cultured from the hair, no parasites were apparent in skin scrapings, and no yeast could be demonstrated cytologically. Skin biopsies from three sites exhibited moderate hyperkeratosis and mild dermatitis. There was mild to moderate lymphoplasmacytic perivascular inflammation with prominent hyalinized blood vessel walls. Ulcerations due to self-trauma were located on the lower lip, on the back and ventral abdomen, and on all legs. The lesions were initially treated topically with miconazole cream (Conofite Cream 2%, Mallinckrodt Veterinary Inc., Mundelein, Illinois 60060, USA) and were cleansed daily with a dilute chlorhexidine solution (Nolvasan Solution, Fort Dodge Animal Health, Overland Park, Kansas 66210, USA) for 16 days. Pruritus was intermittent. This initial treatment was discontinued after skin cultures were negative for fungus. Aloe vera gel (Banana Boat Aloe Vera Gel, Sun Pharmaceuticals, Delray Beach, Florida 33447, USA) was applied to an abrasion on the lower lip b.i.d. for 8 days. The pruritus resolved and the lesions healed.

The pruritus recurred in late June 1995, manifested by rubbing and excoriating the lips, nose, lateral trunk, deep excoriations over the anterior as-

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pect of both hock joints, and intermittent epiphora. Hematology and serum enzyme panels were again within normal limits, and skin scrapings and fungal culture were again negative for organisms. The pruritus persisted intermittently until October. Because the camel was pregnant, systemic treatments with steroids were avoided, and the lesions were treated with medicated shampoo (Micro Pearls Coal Tar Shampoo, Evsco Pharmaceuticals, Buena, New Jersey 08310, USA) or medicated spray (Micro Pearls Advantage Anti-Itch Spray, Evsco Pharmaceuticals) and topical silver sulfadiazene cream (Silvadene cream, King Pharmaceuticals, Bristol, Tennessee 37620, USA). A pyrethrin-based fly repellent ointment (Fly Repellent Ointment for Wounds & Sores, Veterinary Products Laboratories, Phoenix, Arizona 85067, USA) was applied to the lesions. The deep excoriations on both hock joints were treated by daily irrigation with dilute povidone iodine solution (Betadine Solution, The Purdue Frederick Company, Norwalk, Connecticut 06850, USA) and were wrapped to protect them from further trauma. These lesions took several months to fully resolve.

During the next several years, the camel developed pruritus in mid-to-late summer, which resolved as the weather cooled, usually in September or October. The pruritus was generally treated with a variety of topical agents (Panolog, Solvay Animal Health Inc., Mendota Heights, Minnesota 55120, USA; Dermacool-HC with hydrocortisone 1% spay, Allerderm/Virbac Inc., Fort Worth, Texas 76137, USA; Topagen Ointment, Schering-Plough Animal Health Corp., Omaha, Nebraska 68103, USA) or aloe vera gel, whereas 0.2% permethrin fly repellent (Buzz-Off II, Bio-Ceutic Boehringer Ingelheim Animal Health Inc., St. Joseph, Missouri 64502, USA; s.i.d. to b.i.d.) was applied to the face, legs, body, and around the areas of excoriation. There was generally not a serious fly problem at the facility. Episodes of pruritus were effectively controlled by intermittent injections of diphenhydramine (Benadryl, Parke-Davis, Morris Plains, New Jersey 07950, USA; 500 mg, i.m.) and prednisolone acetate (Predate, Legere Pharmaceuticals, Scottsdale, Arizona 85260, USA, 0.3–0.5 mg/kg, i.m.) given s.i.d. for 1–10 days, with an average of 7 days. From 1995 to 2000 the pruritus was observed 18–35 days per year from June to November with 1–2 wk between pruritic episodes.

Pruritus and bilateral epiphora began in mid-June 2001, and injections of diphenhydramine and prednisolone were started immediately. However, pruritus worsened, with the camel rubbing and excoriating its face, trunk, and legs and persisted until

mid-December. Injections of prednisolone and diphenhydramine were administered more frequently and for a longer time period. The camel exhibited pruritus during 49 days in 2001. Pruritus also recurred within 24–48 hr of treatment discontinuation.

Injectable diphenhydramine became temporarily unavailable during late September 2001, and the oral form of diphenhydramine hydrochloride (Benadryl Capsules, Parke-Davis) was started at a dose of 500 mg, p.o., s.i.d. The pruritus worsened and the oral diphenhydramine dose was gradually increased to 1,500 mg, p.o., b.i.d. during the next 3 wk. The pruritus improved but was still evident intermittently. The camel had large areas of alopecia on the face and trunk, with the hair coat appearing disheveled (Figs. 1, 2). Serum was submitted for an enzyme-linked immunosorbent assay (ELISA) veterinary allergy “spot” testing (Spectrum Labs Inc., Mesa, Arizona 95211, USA) using a test validated for horses, not camels. The allergens tested are shown in Table 1 and the positive results in Table 2. Serum from a healthy Bactrian camel yielded similar values, so the ELISA results alone were not used as a basis for hyposensitization but were considered in combination with the results of subsequent intradermal testing.

Biopsies from the skin of the lower abdomen and right shoulder revealed a chronic, ulcerative, eosinophilic, and lymphoplasmacytic superficial perivascular dermatitis with moderate follicular atrophy and superficial pyoderma. The histopathology report was suggestive of a hypersensitivity response with secondary changes because of bacterial infection or corticosteroid administration (or both).

In February 2002, the camel was sedated using xylazine (Rompun, Bayer Corp., Shawnee Mission, Kansas 66201, USA; 55 mg, i.m.). Blood was drawn for hematology and serum biochemistries. A 40- by 30-cm area was shaved over the right shoulder, and an intradermal test (IDT) was performed using 62 allergens regionalized to Northern California (Table 1)⁴ and obtained as concentrates from Greer Laboratories (Lenoir, North Carolina 28645, USA). All allergens were stored in the original glass vials in a standard refrigerator, at approximately 0–4°C, and diluted 24 hr before the IDT. Allergens were used at a dilution of 1,000 protein nitrogen unit (pnu)/ml, unless otherwise noted in Table 1. Saline was used as the negative control and histamine (1:1,00,000 w/v) as the positive control. Approximately 0.05–0.1 ml of each allergen and the controls were injected intradermally. Results were interpreted 15 min after injection and were subjectively graded on a scale of 0–4 accord-



Figure 1. Alopecia on head and face of a pruritic female Bactrian camel.

ing to the approximate diameter, height, firmness, and erythema of the wheal. The negative control was graded as “0” and the positive control was graded as “4”. All results greater than “2” were considered positive.

Seventeen test sites had positive results (Table 2). The strongest reactions (4) were to English plantain, sorrel, and perennial rye. Allergens for hypersensitization were chosen on the basis of these tests and on exposure and availability; two allergens (al-

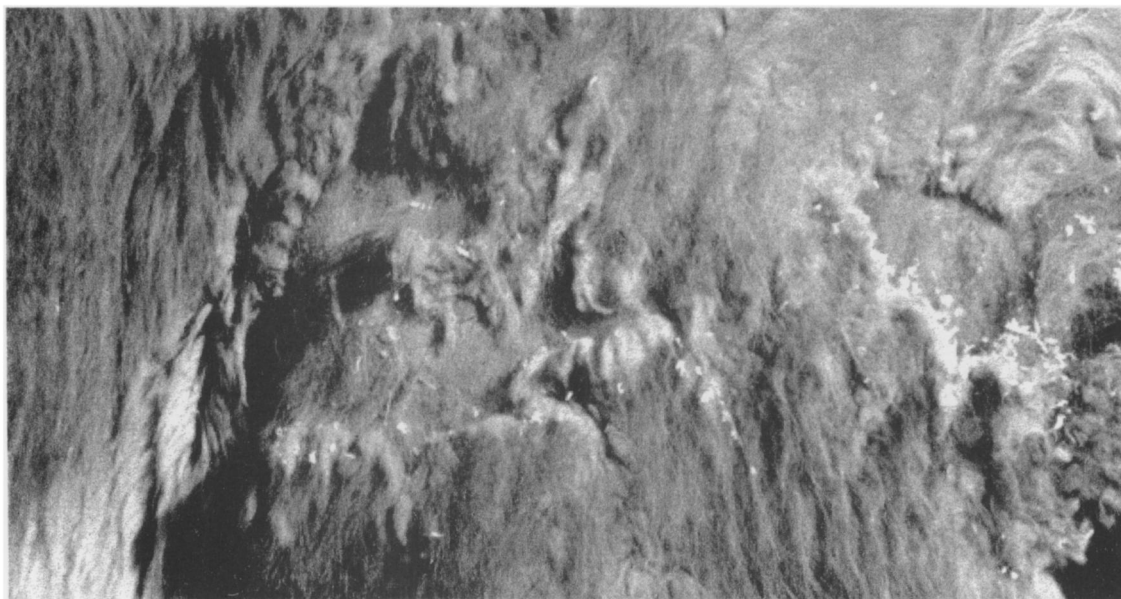


Figure 2. Disheveled hair coat and alopecia of the lateral trunk of a pruritic female Bactrian camel.

Table 1. Allergens used in serologic (enzyme-linked immunosorbent assay) and intradermal skin tests.

Dust mites (highest concentration in summer and fall) <i>Dermatophagoides pteronyssinus</i> ^a 1:1,000 w/v <i>D. farinae</i> ^a 1:1,000 w/v	Weed pollens (late summer and fall) Dandelion ^{ab} Western ragweed ^{ab} English plantain ^{ab} Russian thistle ^a Yellow dock ^{ab} Lambsquarter ^{ab} Red/sheep sorrel ^{ab} Rough pigweed ^{ab} Sage mix ^a Firebush ^b Cocklebur ^b Mugwort ^b Marsh elder ^b Saltbush ^b
Dust House dust ^{ab} Grain mill dust ^a 1:1,000 w/v Grain smut ^a 500 pnu/ml Barn dust ^b	Cultivated plants (spring and summer) Alfalfa ^{ab} Corn ^{ab} 250 pnu/ml Cultivated oat ^{ab} Mustard ^{ab} Perennial rye ^a Sugar beets ^{ab} Cultivated wheat ^{ab} Barley ^b Linseed ^b Cottonseed ^b Pasture mix ^b Soybean ^b White clover ^b
Indoor allergens Sheep epithelia ^{ab} Cat epithelia ^a Pyrethrum ^a Tobacco ^a Mouse epithelia ^b Feather mix ^a 500 pnu/ml Tobacco ^a Pine shavings ^b Redwood shavings ^b Cedar shavings ^b Leather ^b Jute/sisal ^b Cotton ^b	Molds (mid to late summer) <i>Mucor plumbeus</i> ^{ab} <i>Aspergillus niger</i> ^{ab} <i>Pullularia pullulans</i> ^{ab} <i>Penicillium notatum</i> ^{ab} <i>Fusarium moniliforme</i> ^{ab} <i>Hormodendrum hordei</i> ^{ab} <i>Curvularia specifera</i> ^{ab} <i>Alternaria tenuis</i> ^{ab} <i>Rhizopus</i> ^b <i>Cephalosporium</i> ^b <i>Botrytis</i> ^b <i>Stemphylium</i> ^b <i>Cephalothecium</i> ^b <i>Helmithosporium</i> ^b <i>Trichoderma</i> ^b <i>Rhodotorula</i> ^b
Trees and shrubs pollens (late winter and spring) White alder ^{ab} Olive ^{ab} Orange tree ^{ab} Arizona ash ^a Eucalyptus ^{ab} White mulberry ^{ab} Box elder ^a Acacia ^{ab} English walnut ^a Arizona cypress ^a 1:1,000 w/v White birch ^{ab} Chinese elm ^a California white oak ^{ab} Red maple ^a Western sycamore ^a Red cedar ^{ab} Privet ^{ab} Cottonwood ^b	Insects Deer fly ^a House fly ^a 500 pnu/ml Black ant ^a 200 pnu/ml American cockroach ^a Mosquito ^a Culicoides ^{ab} 1:5,000 w/v Flea ^{ab} 1:1,000 w/v Stable fly ^b
Grass pollens (early spring and summer) Bermuda grass ^{ab} Johnson ^{ab} Kentucky blue ^{ab} Fescue ^b Orchard ^b	

^a Intradermal skin test (allergens were tested at a dilution of 1,000 pnu/ml unless otherwise noted); pnu = protein nitrogen units.^b Enzyme-linked immunosorbent assay pollination times and allergen seasonality are in parentheses.¹¹

Table 2. Positive results from Enzyme-linked immunosorbent assay allergen and intradermal skin tests.

Positive enzyme-linked immunosorbent assay allergen test	Positive results from intradermal skin test
Indoor	Dust mites
Redwood shavings	<i>D. pteronyssinus</i> ^a
Jute/sisal	<i>D. farinae</i> ^a
Trees	Indoor allergens
Cottonwood	Feather mix ^a
Alder ^a	
Elm	Trees and shrubs pollens
Mulberry	White alder ^a
Sycamore	Orange tree ^a
	Eucalyptus ^a
Fungi	Acacia ^a
<i>Curvularia</i>	White birch ^a
<i>Hormodendrum</i>	California white oak ^a
<i>Cephalosporium</i>	Privet
<i>Mucor</i>	Sage ^a
<i>Trichoderma</i>	
<i>Rhodotorula</i>	Grass pollens
<i>Pullularia</i>	Bermuda grass ^a
<i>Aspergillus</i>	
<i>Penicillium</i>	Weed pollens
	English plantain ^a
Cultivated plants	Russian thistle ^a
Alfalfa ^a	Red/sheep sorrel
Linseed	
Soybean	Cultivated plants
Oat	Alfalfa ^a
	Mustard
Insects	Perennial rye ^a
Culicoides	Sugar beets
Stable fly	Cultivated wheat

^a Allergens used in the hyposensitization therapy.

der and alfalfa; Table 2) that had yielded positive ELISA results were also included. On 26 February 2002, the camel was started on s.c. hyposensitization injections according to the protocol in Table 3. On day 28 of the initial hyposensitization therapy protocol, the full-strength dose of 1 ml s.c. of the 20,000 pnu/ml was reached. The camel was maintained on that dose once a week throughout the subsequent years.

From June to October 2002, the camel had five mild episodes of pruritus. Successful treatment for four of these episodes included single injections of dexamethasone (Dexamethasone Injection, The Butler Company, Dublin, Ohio 43017, USA: 20–30 mg, i.m.) and diphenhydramine (500 mg, i.m.). One pruritic episode in mid-August lasted 7 days and required two treatments with diphenhydramine and dexamethasone. Fly repellents and topical cor-

Table 3. Protocol for hyposensitization.

Vial 1 (200 pnu/ml)		Vial 2 (2,000 pnu/ml)		Vial 3 (20,000 pnu/ml)	
Day	Amount (ml)	Day	Amount (ml)	Day	Amount (ml)
0	0.1	10	0.1	20	0.1
2	0.2	12	0.2	22	0.2
4	0.4	14	0.4	24	0.4
6	0.8	16	0.6	26	0.8
8	1.0	18	1.0	28	1.0 ^a

^a 1.0 ml of the same concentration is then given once a week.

tisone products (Topagen, Panalog, or Dermacool-HC) were used on the mild excoriations on the legs. Twelve days of pruritus were noted in 2002.

From June to October 2003, there were only four 1-day episodes of pruritus, each controlled by a single injection of diphenhydramine and dexamethasone with dosages similar to those given the previous year. The amount of epiphora and pruritus seen in the 2 yr after the hyposensitization treatment was initiated was markedly less severe and resolved much more quickly after treatment with the diphenhydramine and dexamethasone than the pruritic episodes before the hyposensitization treatment. On physical examination in October 2003, the areas of alopecia and excoriation had resolved, and the hair coat had regrown normally.

DISCUSSION

Atopic dermatitis has been characterized as a type I hypersensitivity disorder, in which antibodies (immunoglobulin [Ig]E and possibly IgG) are formed after exposure to allergens. Consecutive enzymatic reactions are initiated on mast cell and basophil surfaces, resulting in the release of inflammatory mediators. It is most often associated with IgE antibodies to environmental allergens.^{5,10,16} Early sensitization with environmental allergens is important in the development of atopic dermatitis.¹⁶ Therefore, although genetic factors are important, environmental factors may play an even greater role in humans and dogs.⁹ It is not known how this may apply to camels.

Atopy tends to appear early in life. In horses and dogs, clinical signs often begin at 1.5–6 yr of age and before 1.5 yr of age, respectively.^{10,14} This camel was 9-yr of age when signs were first noted; Bactrian camels can live to be 25 yr of age.

Major dermatologic signs of equine atopy are pruritus and urticaria.^{4,5,14} Bilaterally symmetric pruritus commonly involves the face, pinnae, tho-

rax, abdomen, and legs—areas affected in this camel.

Atopic dermatitis is diagnosed by exclusion, so, food hypersensitivity, insect-bite hypersensitivity, and other ectoparasitic diseases needed to be ruled out. Although chorioptic, sarcoptic, and psoroptic mange have been reported in camelids,² skin scrapings and biopsies of the camel were negative, and no other camels on the premises exhibited pruritus. The camel's diet was the same throughout the year but the pruritus was seasonal in nature. The camel had positive intradermal reactions to alfalfa, a staple part of its diet. The camel may have been exposed to alfalfa pollen while feeding, thus contributing to the signs of atopic dermatitis. Although the feed was checked daily for mold before it was offered to the animals and protocol required all moldy hay to be discarded, there may have been mold present on the hay occasionally. It seems unlikely that this would occur only during the warmer summer and fall months.

Although insect-bite hypersensitivity can also occur seasonally, good fly control did not decrease the frequency or intensity of pruritus. Insect-bite hypersensitivity may have contributed to pruritus in this camel, but it was not, probably, the primary cause.

A positive response to the desensitization therapy with no change in diet or management also indicates atopy.

The high IgE titers to various allergens detected in in vitro tests should be interpreted cautiously because the test has not been validated for camels. In vitro tests ideally need to be performed with species-specific anti-IgE antisera to have reliable IgE titers.^{14,16} Because there is no camel anti-IgE antiserum commercially available, the test was performed with horse anti-IgE antiserum. The horse anti-IgE may have cross-reacted with camel IgE and caused false-positive results. The in vitro test positive results with serum of a healthy, nonpruritic camel could have been because of subclinical hypersensitivities or nonspecific reactivity. Similar results have been noted in dogs and horses.^{5,10,16} Although in vitro allergen testing should not be performed as a diagnostic test, it may, with further study, prove useful in defining which allergens could be used for hyposensitization.

Positive IDT results indicate only that the patient has antibodies to these allergens, with mast cells degranulating upon antigen exposure with a subsequent target tissue response to the released mediators. They do not necessarily indicate clinical allergy to those allergens. Relevant positive allergy

test results should correlate to the clinical history of the allergic patient.

The camel's strongest IDT reactions were to English plantain, sorrel, and perennial rye, each of which has its pollination in summer.¹¹ The strongly positive reactions to the house dust mites *Dermaphagoides farinae* and *D. pteronyssinus* may be correlated with the fact that the camel spent more time in the stall during the summer and the fall of 2001, when house dust mite populations are highly concentrated.¹⁶ Although house dust mites have not been reported in camel barns, allergic horses may have positive reactions to these mites.³ Finally, there may be cross-reactivity in individual dogs and humans between other species of mites found in barn dust and *D. pteronyssinus*.^{1,6,7} Positive house dust mite skin test reactions may therefore be clinically significant, even if mites are not present in large numbers in barns.

Corticosteroid therapy, with or without antihistamines, controlled the pruritus until 2001, when increased frequency and duration of treatment became necessary. The temporary unavailability of injectable diphenhydramine in late September 2001 could have contributed to larger total number of days when pruritus was noted. Orally administered diphenhydramine had little effect, even at six times the daily i.m. dose. It may have been inactivated in the rumen.

This camel's immunotherapy protocol is used in horses and dogs at the School of Veterinary Medicine at the University of California, Davis.¹⁶ Sixty to 75% of dogs and horses improve clinically in response to immunotherapy.^{10,14,17} In horses, improvement can be seen within 2–3 mo.¹⁴ The camel was relatively free of clinical signs when the hyposensitization protocol started at the end of February, and less pruritus than expected was noted within 5 mo. In dogs, 50–65% of atopic dogs receiving immunotherapy may require additional medication with antihistamines, fatty acids, or glucocorticosteroids (or all).^{10,15} Occasional flares of pruritus in the camel necessitated occasional antihistamine or corticosteroid use. On several occasions, these flares coincided with cutting vegetation close to the camel. Although the vegetation was not identified, this suggests that a critical amount of aerosolized allergen was responsible for some of the pruritus and supports an aeroallergenic trigger of the clinical signs.

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