

Long-term management of horses with atopic dermatitis in southeastern England: a retrospective questionnaire study of owners' perceptions

Anette Loeffler^{*a} , Desiree Herrick^{*.1}, Serena Allen^{*.2} and Janet D. Littlewood[†]

^{*}Department of Clinical Science and Services, Royal Veterinary College, North Mymms, Hertfordshire, AL9 7TA, UK

[†]Veterinary Dermatology Referrals, Landbeach, Cambridge, UK

Correspondence: Anette Loeffler, Department of Clinical Science and Services, Royal Veterinary College, Hawkshead Lane, North Mymms, Hertfordshire, AL9 7TA, UK. E-mail: aloeffler@rvc.ac.uk

Background – Allergic pruritus and urticaria in the horse are challenging for veterinarians and owners; little is known about their long-term management.

Objectives – To summarize intradermal allergen test results (IDT), and to assess owners' perceptions of skin disease and the effects of medical treatment and management changes in their atopic horses over time.

Animals – Eighty two horses with atopic dermatitis in southeastern England between 2006 and 2011.

Methods and materials – The IDT results were reviewed retrospectively. Owners completed telephone questionnaires on skin changes, medication, effect of allergen-specific immunotherapy (ASIT) and management.

Results – Sixty one owners (74.4%) could be contacted, an average of 5.9 years (range 28–88 months) after IDT; of those, three could not be enrolled. Of the 58 remaining horses, eleven (19%) were deceased at the time of owner interview, including four (6.9%) euthanized due to uncontrollable skin disease. The remaining 47 owners reported that the signs of skin disease had not been seen for at least two years in 18 horses (38.3%), including two that only flared with known triggers. Twenty nine horses (61.7%) still required medication to control skin disease although 25 (53.2%) required less since testing. Owners reported benefit from ASIT in nine of 14 horses (64.3%) from glucocorticoids in 33 of 35 (94.3%) and from antihistamines in 17 of 28 (60.7%). Specific management changes were implemented for 22 horses and reported as beneficial in nine of 22 (40.9%).

Conclusions – Equine atopic dermatitis may not always be chronic, but severe cases appear difficult to control. IDT may help to formulate ASIT and can help to guide management changes.

Introduction

The management of pruritus and urticaria due to allergic skin disease in the horse is challenging for veterinary surgeons and owners, and little is known about the long-term treatment requirements and progression of the disease over time.

In the horse, atopic dermatitis (AD), as a hypersensitivity reaction to environmental allergens and food, presents with pruritus or urticaria or both.^{1–8} It is typically described as a lifelong condition requiring ongoing treatment interventions; signs may be seasonal or perennial,

depending on the causal allergens.⁹ Allergens commonly implicated in many reports include house dust and storage mites, insects, pollens and epithelia.⁶ As for other veterinary species, the diagnosis of equine AD is a clinical diagnosis based on compatible history, clinical signs and exclusion of other differential diagnoses such as ectoparasite infestations, *Culicoides* hypersensitivity and other insect bite hypersensitivities (IBH), and if possible adverse food reactions. Management strategies include allergen avoidance, topical therapies^{10,11} and systemic medications such as antihistamines, glucocorticoids and tricyclic antidepressants.⁹ Dust and moulds can be found in high concentrations in various feeds and bedding materials^{10,12}, and implementation of allergen reduction measures has been shown to be beneficial in some horses with recurrent airway disease^{13,14} and in 18 of 19 horses with nonsummer seasonal and perennial pruritus with or without urticaria.¹⁵

Management strategies may also include allergen-specific immunotherapy (ASIT) based on the results of allergen-specific IgE detected by intradermal testing (IDT) and serological methods.^{3,7,16–21} Positive IDT reactions may occur in normal horses, whereas atopic horses show more numerous and stronger positive reactions.^{3,22} Studies have reported variable efficacy of ASIT in equine AD,

Accepted 23 July 2018

¹Present address: Unit 1A Old Market Retail Park, High Street, Pitsea, Basildon, Essex, SS13 3BY, UK.

²Present address: Haven Veterinary Practice, 35 Holland Road, Clacton-on-Sea, Essex, CO15 6EH, UK.

Conflict of interests: No conflict of interests have been declared.

Sources of funding: This study was self-funded.

This study was presented at the European Society of Veterinary Dermatology-European College of Veterinary Dermatology annual congress, 2014, Salzburg, Austria. *Vet Dermatol* 2014; 25: 396 (Abstract).

with up to 84% of cases showing good to excellent response to ASIT based on the results of intradermal testing.^{1,4,8,23–25} In one study, in horses where glucocorticoids could be stopped, 59% were well controlled with ASIT as the sole treatment and 9% of the partial responders needed doxepin in addition to ASIT. In 44% of cases, ASIT was stopped due to resolution of clinical signs, with two thirds of these reporting no recurrence of disease, but recurrence of clinical signs occurred within 1–12 years of stopping ASIT in the remaining one third.⁸

The aims of this study were to investigate the progression of AD in horses after IDT and to summarize their IDT results. Owners' perceptions and reports on their horses' skin disease, on medical treatment utilized, including ASIT, and the effects of management changes over time were investigated through telephone questionnaires.

Methods and materials

The study had been approved by the Royal Veterinary College (RVC) Ethics and Welfare committee (R349).

Study population

Horses with suspected AD which had been referred for intradermal testing to one of two dermatology referral centres in southeastern England between 2006 and 2011 were enrolled. Horses had been diagnosed initially with allergic skin disease by their referring veterinary surgeon. At referral, allergic dermatitis was confirmed clinically based on a history and presenting signs of pruritus and/or urticaria after ectoparasite infestations and microbial infections had been ruled out. Dermatological examination was performed combined with microscopic examination of skin scrapings, coat brushings and/or with anti-ectoparasite therapy, cytological examination of lesions, and fungal or bacterial culture or antimicrobial therapy when indicated. Insect bite hypersensitivities were ruled out by confirming nonsummer seasonal or perennial disease from the medical records. Food hypersensitivity was discussed with every owner, and elimination diet trials were recommended; IDT was performed irrespectively, based on suspected AD.

Information on signalment (age, sex, breed or type), cutaneous signs relevant for referral for IDT (pruritus, urticaria, both, seasonality), previous therapy including response (glucocorticoids, antihistamines) and elimination diet trials was collected from electronic or paper medical histories as far as available.

Intradermal testing

All horses were tested using procedures as described previously⁶ against allergens considered relevant including environmental mites and epithelia including feathers and pollens (grasses, weeds and flowers, trees). In addition, allergen solutions of insects, fungi, grain crop pollens, house dust, grain mill dust and smut were included when available. Allergen test kits varied minimally in their composition over the six year duration of the study due to differing availability of allergen solutions and preferences of referral centres. Allergens used were recorded for each horse from the medical records. Allergen solutions had been sourced over time from one of two manufacturers (Greer Laboratories; Lenoir, NC, USA, or ArtuVet; Lelystad, Netherlands) with concentrations and dilutions given in Table S1.

Reactions were considered positive if the diameter of the wheal was greater than the mean of the positive and negative controls measured at 30 min. Wheal sizes were assessed at 30 min and 2–4 h (considered immediate and late-phase IgE-mediated reactions). Additional observations were made at 12–24 h to assess for delayed reactions. ASIT was offered for all horses showing positive reactions to allergens presumed to be clinically relevant and suitable for inclusion (indoor allergens, epithelia, pollens) and not for horses only showing reactions to moulds, fungi and insects.

Management changes were recommended for all horses, depending on groups of allergens implicated by IDT (indoor allergens and dusts, epithelia, pollens, insects) to reduce exposure (Table S2). At Veterinary Dermatology Referrals (VDR), specific changes recommended included use of rubber matting in stables with minimal or no loose bedding, feeding of vacuum-packed, wilted grass products to replace hay and feeding of pelleted concentrate foods stored for only short periods in original packaging, regular, frequent rug laundering and quarterly pressure cleaning of stables, removal of bird nests and use of selective weed killer, if relevant.

Owner recruitment

Owners were telephoned between September 2013 and March 2014 and asked for their participation in a telephone questionnaire study on their horse's skin disease, medication, effect of ASIT and implementation of management changes since IDT. Owners were called from known telephone numbers (number not withheld by the caller) by the same investigator (DH) up to three times if there was no reply and no answering machine and up to two messages were left on answering machines before the case was excluded due to failed contact. Owners were not contacted if a horse was known to be dead since the IDT. For horses reported deceased by their owner during the telephone contact, the cause of death was recorded, but they were not asked to complete the questionnaire.

Questionnaires

Questions were divided into three broad topics. First, owners were asked to assess their horse's skin problem at the time of the telephone questionnaire and at the time of IDT. They were asked to describe skin signs as pruritic, urticarial, both or other, whether changes in type or distribution of problems had been observed since IDT and whether other skin problems had been diagnosed by their veterinarian since IDT. Owners were asked to assess the severity of itching and/or urticaria and provide a score between 0 and 10 (an unvalidated empirical score system; with 0 for normal/never and 10 for severe/present all the time).

Secondly, questions on medication and other treatments, specifically glucocorticoids, antihistamines, ASIT, antidepressants, nutritional supplements and washes, were asked. Sub-questions for each treatment were whether the horse had ever received it, was currently receiving it and how frequently (seasonally, throughout the year), whether the treatment was tolerated and whether the owner thought the treatment had improved skin problems.

Thirdly, owners were asked about their horses' current management and on implementation of management changes recommended at time of IDT (Table S2), including whether they had changed barn or paddock, where the horse spent most of its time, type of bedding used, rugging (type, time spent wearing rugs and frequency of laundering), clipping (frequency and extent) and ectoparasite and fly control measures. For each question, owners were asked whether they considered those changes beneficial to their horse's skin problem.

An option to answer 'unsure' or 'unknown' was included where appropriate. The questionnaire was trialled in six pilot calls and adjusted based on feedback. Each questionnaire was estimated to take 20 min including a short introduction outlining the study purpose, confidentiality provisions and the option to decline. At the end of the questionnaires, owners were offered contact details of investigators.

Data analysis

Microsoft Excel (Microsoft, v15.38, 2017) was used for data collection and SPSS version 23.0 (IBM; Armonk, NY, USA) for analysis.

Results

Enrolled horses and owners

Eighty two horses had undergone IDT for suspected AD during the study period, 15 from the RVC, and 67 from

VDR (original starting population). Ages at time of IDT ranged between one and 25 years (mean 9.9 years). There were 40 mares, 40 geldings, one stallion and one horse of unknown sex. Breeds or types varied, with 23 recorded as cob or pony, mostly Welsh cob, 21 as thoroughbred including thoroughbred crosses, seven Irish sports horses, eight warmbloods and 23 other types. Pruritus was the presenting complaint in 36 horses (43.9%), urticaria in 34 horses (41.5%) and 12 (14.6%) presented with both. In most horses (67 of 82, 81.7%), lesions were reported as generalized. Of the 15 horses with localized lesions, eight showed signs only on the trunk, six on the head and one on the legs. All animals suffered from skin disease during the winter months, for 19 horses (23.2%), owners reported additional seasonal flares during spring or summer.

Owners of 61 (74.4%) horses were contacted by telephone. For the remainder, either contact details were not available or attempts to make contact as described above had failed. One owner declined participation, and two could not provide answers because the horses had been sold soon after IDT. The time between IDT and telephone questionnaire for the 58 horses ranged between 28 and 88 months (mean 71 months or 5.9 years).

At the time of telephone contact, eleven of the 58 (19.0%) horses were reported dead, including four (6.9%) euthanized due to uncontrollable skin disease (three with pruritus, one with urticaria). One had died a spontaneous death of unconfirmed cause, five had been euthanized for known diagnoses [brain tumour, lymphoma, colic, lameness (investigated and confirmed as nonlaminitic), kissing spines] and one horse for old-age related reasons.

Intradermal tests

The average number of allergens each horse was tested against was 54.2 [standard deviation (SD) 10], and the average number of positive reactions per horse was 13 (SD 8.1). Two horses had shown no positive wheal and flare reactions to any of the allergens despite strong histamine test reaction. The allergens tested in at least 50 horses and which resulted in positive reactions in at least 25% of horses are listed in Table 1. Most (1,247; 96.1%) of the 1,297 positive reactions recorded in total occurred at the early readings considered compatible with immediate and late-phase hypersensitivity reactions. At the later time points, compatible with delayed reactions, 122 (9.4%) positive reactions were recorded – 72 at sites of earlier readings, 50 (3.9%) distributed over all allergen groups – that had not been recorded at earlier time points.

Skin disease – owner assessment

Of the 47 horses for which follow-up information was available (14 RVC, 33 VDR), owners considered their horse's skin disease at the time of telephone contact as resolved without medication in 18 cases (38.3%), as improved with treatment in 25 cases (53.2%) and as unchanged or worse despite medication in four cases (8.5%). Six of the 18 horses that no longer had skin problems at the time of telephone contact had been lesion-free since the time of IDT whereas another ten had not had skin disease for at least the previous

2 years. Four of these 18 horses had had management changes implemented after IDT (see below), and two further horses only showed skin disease after known triggers (cereal-based food or treats, shavings). The remaining 29 horses were still receiving either glucocorticoids or antihistamines throughout the year or at least three times a year during flares. Six owners reported that their horses had been diagnosed with pituitary pars intermedia dysfunction since IDT and that new, different skin lesions had developed (crusting papules, urticaria in previously pruritic horses and vice versa).

Owners' assessment of pruritus, irrespective of medication or management used, on a 1–10 scale gave a median of 9 (range 3–10) at the time of IDT and of 1.5 (range 0–6) at the time of telephone contact. Median scores for the frequency of urticaria flares were 8 (range 2–10) at the time of IDT and 2 (range 0–7) at telephone contact.

Medication and immunotherapy – owner assessment

Systemic glucocorticoids had been used in 35 of 47 horses (74.5%) to control skin disease since IDT, including seven still receiving treatment at the time of telephone contact. Good response to glucocorticoid therapy was reported in 94.3% of horses (33 of 35) after IDT, whereas good response had been recorded in 78.2% of the 55 horses that had been treated with glucocorticoids prior to IDT (plus a further 5.5% showing partial response). Adverse effects of post-IDT glucocorticoid therapy were reported by owners in seven of 35 (20%) including laminitis in one heavy draft horse (which according to the medical records was recorded as a foot abscess and without further mention of laminitis in the medical records during the subsequent two years), two horses with flares of pre-existing laminitis, and one each with drowsiness, weight gain or behaviour changes.

Twelve owners reported using topical glucocorticoid preparations (hydrocortisone aceponate spray (Cortavance, Virbac; Bury St Edmunds, UK) $n = 6$; fusidic acid/betamethasone combination (Fuciderm, now Isaderm, Dechra Veterinary Products; Shrewsbury, UK) $n = 4$; unknown human eczema cream $n = 1$) and all but one owner observed a beneficial effect when the product was applied at least daily.

Twenty eight horses (59.6%) had received antihistamines (type unknown) at some stage since IDT to control their cutaneous signs, and good response was reported in 17 of these 28 horses (60.7%). Eight horses were still maintained on antihistamines as the sole medication at the time of telephone contact. Drowsiness was the only adverse effect reported in three horses.

ASIT had been ordered for 27 horses (57.5%), but its use was reported only by owners of 14 of 47 horses (29.8%) with nine owners of these 14 horses (64.3%) reporting a beneficial effect including eight reporting a 75–100% improvement. In only three horses was immunotherapy continued beyond the first prescribed immunotherapy vial of at least nine months; in one of them, antihistamines were given concurrently throughout. A further two horses were restarted on ASIT when clinical signs relapsed after immunotherapy had been discontinued following completion of injections with the initial vial. Restarting ASIT was perceived as helpful again in

Table 1. Allergens used for intradermal testing in at least 50 of the 82 horses and resulting in positive reactions in 25% or more of horses

Allergen	No. of positive reactions of horses tested	% Positive	Kit (Greer Laboratories or Artu Biologicals)
<i>Dermatophagoides farinae</i> (farina mite)	76 of 85	89.4	Both
<i>Dermatophagoides pteronyssinus</i> (house dust mite)	74 of 85	87.1	Both
Moth	55 of 65	84.6	Greer
<i>Aedes communis</i> (mosquito)	45 of 65	69.2	Greer
<i>Tyrophagus putrescentiae</i> (copra mite)	53 of 78	68.0	Both
<i>Tabanid</i> (horse fly)	43 of 65	66.2	Greer
<i>Lepidoglyphus destructor</i> (hay mite)	52 of 84	61.9	Both
<i>Acarus siro</i> (flour mite)	51 of 85	60.0	Both
Grain mill dust	39 of 65	60.0	Greer
<i>Culicoides</i> (midge)	34 of 64	53.1	Greer
<i>Trifolium pratense</i> (red clover)	43 of 84	51.2	Both
Grain mill smut	33 of 65	50.8	Greer
Mixed feathers (chicken, goose, duck)	42 of 84	50.0	Both
<i>Urtica dioica</i> (stinging nettle)	32 of 64	50.0	Greer
German cockroach	29 of 65	44.62	Greer
<i>Avena sativa</i> (cultivated oat)	21 of 55	38.18	Greer
<i>Leucanthemum vulgare</i> (daisy)	31 of 84	36.90	Both
<i>Rumex crispus</i> (yellow dock)	23 of 64	35.94	Greer
<i>Solidago virgaurea</i> (golden rod)	30 of 84	35.71	Both
<i>Taraxacum officinale</i> (common dandelion)	22 of 62	35.48	Both
Sheep epithelia	22 of 63	34.92	Greer
<i>Salix viminalis</i> (pussy/black willow)	22 of 64	34.38	Greer
<i>Aspergillus fumigatus</i>	22 of 64	34.38	Greer
<i>Artemisia vulgaris</i> (common mugwort)	23 of 84	27.38	Both
<i>Rhizopus nigricans</i>	14 of 55	25.45	Greer

House dust and black ant also showed reactions in 71.5% and 70%, respectively, but were only tested in 14 and in 30 horses, respectively.

both cases. The remaining nine horses no longer received ASIT at the time of telephone contact. Six owners stated they thought they had finished the treatment after the initial vial (typically nine months), including three in which treatment was thought to have had no effect. Another two owners stopped ASIT before completing the initial vial due to lack of effect, and one owner stated expense as the reason for stopping. Twelve owners reported administering the maintenance injections themselves (injections by the veterinarian as default administration type). No systemic adverse effects were reported, localized injection site reactions were seen by owners in six of 14 horses (42.9%) on individual occasions, none persisted or required veterinary attention.

Fly prevention was used in 22 (46.8%) horses regularly during the spring and summer. In total, 38 horses (82.1%) were receiving or had received other agents with the aim to control their skin disease since IDT. These included systemic antimicrobial therapy ($n = 1$), shampoo therapy used at least weekly ($n = 18$) with seven owners using chlorhexidine-based products and 11 using products of unknown composition but with claims of alleviating allergic skin signs [and 12 of 38 owners (31.6%) perceiving a beneficial effect]. Skin-related, nonprescription food supplements (various, unknown) had been given by 30 owners (65.2%) without adverse effects reported.

Management changes

Twenty two owners (46.8%) had implemented recommended changes to stables, bedding, feed or rugs, and nine of those (40.9%) reported a perceived subsequent improvement in their horse's skin disease, including four horses for which no additional medication had been needed since. Skin disease was reported to have

improved in three horses after they had been relocated to a different yard, in another three following dietary changes (treats removed from diet), one horse improved when shavings were removed from its stable, and in the remaining two horses, multiple changes had been made concurrently.

Almost all horses (45; 97.8%) were reported to wear rugs at some time during the year with 34 wearing the rug all day during the cooler months. Thirty five of 47 (74.5%) horses were regularly clipped.

Discussion

To the best of the authors' knowledge, this is the first study in the UK to report on the management of atopic horses over time, with a reporting interval greater than two years available for all cases. Although information derived from owner interviews was collected retrospectively and is inevitably associated with a high degree of subjectivity, it still provides a realistic insight into the burden of allergic skin disease on horses and their owners and may help to stimulate future research and improvements in clinical management. In addition, questionnaire data were collected during the colder months of the year in the UK which may have biased reporting. However, in the UK, clinical signs and onset of AD in the horse have been reported throughout the year² and including onset and exacerbation in autumn, suggesting that the impact of seasonality may be less relevant.

The data on clinical signs and IDT results collected from medical records were broadly in line with previous studies,^{8,16} including one in southern England.⁶ Positive reactions to house dust mites, storage mites and insects predominated, likely reflecting exposure to such allergens

through a largely stabled lifestyle and management, including the frequent use of house dust mite-harboring rugs,²⁶ with exposure to biting insects when at pasture.

Results from this study on disease outcome at least two years after IDT were highly surprising, first with regard to the substantial proportion of horses for which owners reported that skin disease had resolved and treatment had not been required for at least two years, and secondly, with regard to the number of deceased horses.

These findings challenge the concept that AD in the horse is chronic and requires lifelong treatment.^{5,7,9} Unfortunately, our data do not allow conclusions to be made on duration of disease before resolution in these horses, and so predictions cannot be made on how long signs might persist in horses with potentially transient presentations. However, the results suggest that, at least in some horses, the prognosis for AD can be excellent and they further corroborate previous advice that it is best to explore possible causes when the disease is recurrent or persistent.²⁷ Whether resolution of skin signs without medication was spontaneous or due to management changes, which were perceived to help by almost half of the owners, remains unknown. The role of allergen load rather than exposure is less clear for AD compared to respiratory lower airway disease in the horse.²⁸ However, in the absence of such data, the benign nature of recommendations on management changes warrants inclusion in the management plan for every atopic horse presented for IDT.

In contrast, the finding that 19% of horses were dead at the time of telephone interview, including 7% (four horses) where owners reported that the animals had been euthanized due to uncontrollable skin disease, is concerning. Although research on the pathomechanisms and treatment options on allergic diseases has progressed substantially over the past decades, the social implications of chronic allergic diseases are only slowly starting to receive attention. Initial results of a survey on health-related quality of life in atopic dogs and on quality of life in their owners showed that the disease had a deeply negative impact on both measures but only 1% of owners stated they had contemplated euthanasia.²⁹ In addition, treatment was considered a major financial burden by a third of dog owners and 40% stated that they had to limit other expenses as a consequence. The questionnaire in our study was not designed to further explore reasons for euthanasia, but the results are likely to reflect some degree of welfare concerns, implications on the use of a horse with skin disease and the financial burden associated with chronic skin disease. Other horse-specific factors also may have played a role and need to be investigated further.

Of the 29 horses for which management of skin disease was still required after IDT, different combinations of antihistamines, glucocorticoids, ASIT and management changes were reported to achieve acceptable levels of control with tolerable adverse effects for most patients and owners. Results on drug efficacy need to be interpreted with care as these were based on owner impressions over time rather than on veterinary assessment following a defined intervention period. However, the high frequencies of beneficial effects reported for

glucocorticoids (94.3%), mainly as oral prednisolone, and for antihistamines (60.7%) provide some assurance on treatment effect. To date, despite their wide use, only review articles describe the use of both medications in the treatment of allergic skin disease in horses and provide some pharmacokinetic information and dose recommendations.^{9,23}

Further study is needed on which therapies or combinations help atopic horses most, and if there is a difference in response to therapies between pruritic and urticarial horses which was not the focus of this study. Slightly more information is available on the use of glucocorticoids for noninfectious lower airway disease where inflammation is thought to contribute to clinical signs.²⁸ Concerns over glucocorticoid use as a risk factor in the development of laminitis are widespread, but the scientific basis for this association is sparse, at least for non-predisposed horses.^{30–32} Results from two studies suggested that such a link may have been overestimated,^{33,34} but due to the critical consequences of laminitis, further research is still needed. In light of the relatively high number of atopic horses in this study, which were euthanized due to uncontrolled disease, with none due to laminitis caused by glucocorticoid therapy, concerns over the potential risk of laminitis need to be balanced against welfare considerations due to uncontrolled AD. In the authors' opinion, glucocorticoids have an important role to play in the management of atopic horses; prednisolone at low doses given on alternate days to horses not predisposed to laminitis would be a recommended strategy.⁹

The benefit of ASIT reported in 64% of horses in this study was lower than the 84% owner-reported efficacy from a North American study of 41 horses receiving ASIT,⁸ but comparable to those found in a previous study.²⁵ However, the low uptake of ASIT following IDT in this study was surprising and disappointing. Reasons for not starting or at least not pursuing therapy were not explored as these findings had been unexpected. Measures have been taken since the conclusion of the study to extend discussion with owners and strengthen recommendations towards ASIT.

Although "much folklore still remains in respect of certain equine skin diseases" as stated in 1970 by the late LR Thomsett,³⁵ the results from the present study on long-term management of allergic horses from the owners' perspective indicate that AD may have a better prognosis than in other companion animals and may not always be chronic. It is still of concern, though, that there was a high number of euthanized horses in this study, suggesting that severe cases may be difficult to control and that the burden of chronic skin disease for owners should not be underestimated. Management changes, following the identification of relevant allergens by IDT, in combination with medication and sometimes ASIT, may help provide effective control of clinical signs.

Acknowledgements

The authors thank owners of horses for their willingness to be involved in this study and their veterinary surgeons for referring the cases.

References

- Fadok VA. Overview of equine pruritus. *Vet Clin North Am Equine Pract* 1995; 11: 1–10.
- Littlewood JD, Paterson S, Shaw SC. Atopy-like skin disease in the horse. In: Kwochka KW, Willemse T, von Tscharner C, eds. *Advances in Veterinary Dermatology* volume 3. Oxford: Butterworth Heinemann 1998; 563–564.
- Lorch G, Hillier A, Kwochka KW et al. Results of intradermal tests in horses without atopy and horses with atopic dermatitis or recurrent urticaria. *Am J Vet Res* 2001; 62: 1,051–1,059.
- Rees CA. Response to immunotherapy in six related horses with urticaria secondary to atopy. *J Am Vet Med Assoc* 2001; 218: 753–755.
- White SD. Advances in equine atopic dermatitis, serologic and intradermal allergy testing. *Clin Tech Equine Pract* 2005; 4: 311–313.
- Rendle DI, Durham AE, Wylie CE et al. Results of intradermal testing for the investigation of atopic dermatitis and recurrent urticaria in 50 horses in the south of England. *Equine Vet Educ* 2010; 22: 616–622.
- Scott DW, Miller WH. *Equine Dermatology*, 2nd edition. St. Louis, MO: Saunders Elsevier; 2011: 263–313.
- Stepnik CT, Outerbridge CA, White SD et al. Equine atopic skin disease and response to allergen-specific immunotherapy: a retrospective study at the University of California-Davis (1991–2008). *Vet Dermatol* 2011; 23: 29–35.
- Rosenkrantz W, White S. Equine atopic disease symptomatic therapy and allergen-specific immunotherapy. In: Noli C, Foster A, Rosenkrantz W, eds. *Veterinary Allergy*. Chichester: Wiley Blackwell, 2014; 360–370.
- De Pater M, van Ree M, van Sloet Oldruitenborgh-Oosterbaan M. Topical hydrocortisone aceponate spray in the horse: unauthorised medication? In: *Proceedings of the European Veterinary Conference -Voorjaarsdagen*. Amsterdam, Netherlands: 2009; 4 (abstract).
- Kietzmann M, Kemmet S. Skin thinning effects of topically administered glucocorticoids in dogs and horses. *Vet Dermatol* 2012; 32 (Suppl 1): 42 (abstract).
- Vandenput S, Istasse L, Nicks B et al. Airborne dust and aeroallergen concentrations in different sources of feed and bedding for horses. *Vet Q* 1997; 19: 154–158.
- Woods PSA, Robinson NE, Swanson MC et al. Airborne dust and aeroallergen concentration in a horse stable under two different management systems. *Equine Vet J* 1993; 25: 208–213.
- Jackson CA, Berney C, Jefcoat AM et al. Environment and prednisone interactions in the treatment of recurrent airway obstruction (heaves). *Equine Vet J* 2000; 32: 432–438.
- Littlewood JD. Incidence of recurrent seasonal pruritus ('sweet itch') in British and German shire horses. *Vet Rec* 1998; 142: 66–67.
- Delger J. Intradermal testing and immunotherapy in horses. *Vet Medicine* 1977; 92: 635–639.
- Lorch G, Hillier A, Kwochka KW et al. Comparison of immediate intradermal test reactivity with serum IgE quantitation by use of a radioallergosorbent test and two ELISA in horses with and without atopy. *J Am Vet Med Assoc* 2001; 218: 1,314–1,322.
- Lebis C, Bourdeau P, Marzin-Keller F. Intradermal skin tests in equine dermatology: a study of 83 horses. *Equine Vet J* 2002; 34: 666–672.
- Kalina WV, Pettigrew HD, Gershwin LJ. IgE ELISA using antisera derived from epsilon chain antigenic peptides detects allergen-specific IgE in allergic horses. *Vet Immunol Immunopathol* 2003; 92: 137–147.
- Morgan EE, Miller WH, Wagner B. A comparison of intradermal testing and detection of allergen-specific immunoglobulin E in serum by enzyme-linked immunosorbent assay in horses with skin hypersensitivity. *Vet Immunol Immunopathol* 2007; 120: 160–167.
- Peterson A, Schott HD. Effects of dexamethasone and hydroxyzine treatment on intradermal testing and allergen-specific IgE serum testing results in horses. *Vet Dermatol* 2009; 20: 615–622.
- Evans AG, Paradis MR, O'Callaghan M. Intradermal testing of horses with chronic obstructive pulmonary disease and recurrent urticaria. *Am J Vet Res* 1992; 53: 203–208.
- Marsella R. Equine Allergy Therapy: update on the treatment of environmental, insect bite hypersensitivity, and food allergies. *Vet Clin North Am Equine Pract* 2013; 29: 551–557.
- Tallarico NJ, Tallarico CM. Results of intradermal allergy testing and treatment by hyposensitization of 64 horses with chronic obstructive pulmonary disease, urticaria, headshaking, and/or reactive airway disease. *Vet Allergy Clin Immunol* 1998; 6: 25–35.
- Rosenkrantz WS, Griffin CE, Esch RE et al. Responses in horses to intradermal challenge of insects and environmental allergens with specific immunotherapy. In: Kwochka KW, Willemse T, von Tscharner C, eds. *Advances in Veterinary Dermatology* volume 3. Oxford: Butterworth Heinemann, 1998; 192–200.
- Wallace JC, Vogelnest LJ. Evaluation of the presence of house dust mites in horse rugs. *Vet Dermatol* 2010; 21: 602–607.
- Fadok VA. Of horses and men: urticaria. *Vet Dermatol* 1990; 1: 103–112.
- Couëtil LL, Cardwell JM, Gerber V et al. Inflammatory airway disease of horses - revised consensus statement. *J Vet Intern Med* 2016; 30: 503–515.
- Linek M, Favrot C. Impact of canine atopic dermatitis on the health-related quality of life of affected dogs and quality of life of their owners. *Vet Dermatol* 2010; 21: 456–462.
- Eyre P, Elmes PJ, Strickland S. Corticosteroid-potentiated vascular responses of the equine digit: a possible pharmacologic basis for laminitis. *Am J Vet Res* 1979; 40: 135–138.
- Johnson PJ, Slight SH, Ganjam VK et al. Glucocorticoids and laminitis in the horse. *Vet Clin North Am Equine Pract* 2002; 18: 219–236.
- Bailey SR, Elliott J. The corticosteroid laminitis story: 2. Science of if, when and how. *Equine Vet J* 2007; 39: 7–11.
- Jordan VJ, Ireland JL, Rendle DI. Does oral prednisolone treatment increase the incidence of acute laminitis? *Equine Vet J* 2017; 49: 19–25.
- Welsh CE, Duz M, Parkin TDH et al. Disease and pharmacologic risk factors for first and subsequent episodes of equine laminitis: a cohort study of free-text electronic medical records. *Prev Vet Med* 2017; 136: 11–18.
- Thomsett LR. Differential diagnosis of skin diseases of the horse. *Equine Vet J* 1970; 2: 46–51.

Supporting Information

Additional Supporting Information may be found in the online version of this article.

Table S1. Allergen solutions and dilutions used for intradermal testing of horses during the study period.

Table S2. Suggestions on management changes provided to horse owners to reduce exposure to environmental mites in atopic horses

Résumé

Contexte – Le prurit allergique et l'urticaire chez le cheval sont des défis pour les vétérinaires et les propriétaires ; on en sait peu sur leur gestion au long cours.

Objectifs – Résumer les résultats des tests allergéniques intradermiques (IDT) et déterminer les perceptions des maladies cutanées par les propriétaires et leurs effets sur les traitements médicaux et les changements de gestion au cours du temps chez leurs chevaux atopiques.

Sujets – Quatre vingt deux chevaux atopiques du sud de l'Angleterre entre 2006 et 2011.

Matériels et méthodes – Les résultats des IDT ont été revus rétrospectivement. Les propriétaires ont complété des questionnaires téléphoniques sur les changements cutanés, les traitements, l'effet de la désensibilisation (ASIT) et la gestion.

Résultats – Soixante et un propriétaires (74.4%) ont pu être contactés, une moyenne de 5.9 ans (28-88 mois) après IDT ; parmi eux, trois n'ont pas pu être enrôlés. Sur les 58 chevaux restants, onze (19%) étaient morts au moment de l'interrogation des propriétaires, dont quatre (6.9%), euthanasiés en raison de la dermatose incontrôlable. Les 47 propriétaires restants ont rapporté que les signes cliniques n'ont pas été observés au cours des deux dernières années minimum pour 18 chevaux (38.3%), dont deux avec des crises liées à des facteurs connus. Vingt-neuf chevaux (61.7%) nécessitaient toujours des traitements médicaux pour contrôler la dermatose bien que 25 (53.2%) en avaient besoin de moins depuis les tests. Les propriétaires ont rapporté un bénéfice de l'ASIT chez neuf des 14 chevaux (64.3%), des corticoïdes dans 33 des 35 (94.3%) et des antihistaminiques des 17 sur 28 (60.7%). Les changements de gestion spécifiques ont été mis en place pour 22 chevaux et rapportés utiles pour neuf sur 22 (40.9%).

Conclusion – La dermatite atopique équine n'est pas toujours chronique, mais des cas sévères semblent difficiles à contrôler. L'IDT peut aider à formuler l'ASIT et peut guider dans les modifications de gestion.

Resumen

Introducción – el prurito alérgico y la urticaria en caballos son complicados para los veterinarios y los propietarios; poco se sabe sobre su control a largo plazo.

Objetivos – presentar los resultados de las pruebas intradérmicas frente a alérgenos (IDT) y evaluar la percepción de los propietarios acerca de la enfermedad de la piel, y los efectos del tratamiento médico y los cambios en el manejo de sus caballos atópicos a lo largo del tiempo.

Animales – Ochenta y dos caballos con dermatitis atópica en el sureste de Inglaterra entre 2006 y 2011.

Métodos y materiales – los resultados de IDT se revisaron de forma retrospectiva. Los propietarios completaron cuestionarios telefónicos sobre cambios en la piel, medicamentos, efecto de la inmunoterapia específica de alérgenos (ASIT) y administración.

Resultados – Sesenta y un dueños (74,4%) pudieron ser contactados con un promedio de 5,9 años (rango 28-88 meses) después de IDT; de ellos, tres no pudieron ser inscritos. De los 58 caballos restantes, once (19%) habían fallecido en el momento de la entrevista con el propietario, incluidos cuatro (6,9%) sacrificados debido a una enfermedad cutánea incontrolable. Los 47 propietarios restantes informaron que los signos de la enfermedad de la piel no se habían visto durante al menos dos años en 18 caballos (38,3%), incluidos dos que solo presentaban enfermedad con alérgenos conocidos. Veintinueve caballos (61,7%) aún necesitaban medicamentos para controlar la enfermedad de la piel, aunque 25 (53,2%) requirieron menos desde la prueba. Los propietarios informaron de un efecto beneficioso de ASIT en nueve de 14 caballos (64,3%); de glucocorticoides en 33 de 35 (94,3%) y de antihistamínicos en 17 de 28 (60,7%). Se implementaron cambios de manejo específicos para 22 caballos y se reportaron como beneficiosos en nueve de 22 (40,9%).

Conclusiones – la dermatitis atópica equina puede no ser siempre crónica, pero los casos graves parecen difíciles de controlar. IDT puede ayudar a formular ASIT y puede ayudar a guiar los cambios en el manejo.

Zusammenfassung

Hintergrund – Allergischer Juckreiz und Urtikaria sind beim Pferd eine Herausforderung für TierärztInnen und BesitzerInnen; es ist wenig bekannt über ein Langzeit Management.

Ziele – Eine Zusammenfassung der Ergebnisse von intradermalen Allergentestergebnissen (IDT), das Erfassen der Wahrnehmung der Hauterkrankung durch die BesitzerInnen und die Auswirkungen der medizinischen Behandlung und den Veränderungen im Management bei ihren atopischen Pferden im Laufe der Zeit.

Methoden und Material – Es wurden die IDT Ergebnisse retrospektiv durchgesehen. Die BesitzerInnen beantworteten einen telefonischen Fragebogen über die Hautveränderungen, die Medikation, die Auswirkung der Allergen-spezifischen Immuntherapie (ASIT) und des Managements.

Ergebnisse – Einundsechzig BesitzerInnen (74,4%) konnten kontaktiert werden, im Durchschnitt 5,9 Jahre (Bandbreite 28-88 Monate) nach dem IDT; von diesen konnten drei nicht in die Studie aufgenommen werden. Von den übrigen Pferden, waren elf (19%) zum Zeitpunkt des BesitzerInneninterviews bereits verstorben, dazu zählten vier (6,9%), die aufgrund von unkontrollierbarer Hauterkrankung euthanasiert worden waren. Die übrigen 47 BesitzerInnen berichteten, dass die Zeichen der Hauterkrankung bei 18 Pferden (38,3%) mindestens zwei Jahre lang nicht sichtbar waren, dazu zählten zwei Pferde, die nur bei bekannter Ursache aufflammten. Neunundzwanzig Pferde (61,7%) benötigten noch immer eine Medikation um die Hauterkrankung zu kontrollieren, obwohl 25 (53,2%) seit dem Test weniger benötigten. Die BesitzerInnen berichteten von einer Verbesserung durch ASIT bei neun von 14 Pferden (64,3%) durch Glukokortikoide bei 33 von 35 (94,3%) und durch Antihistamine bei 17 von 28 (60,7%). Bei 22 Pferden wurden spezifische Management Veränderungen durchgeführt und diese bei neun der 22 (40,9%) als wirksam beschrieben.

Schlussfolgerungen – Die atopische Dermatitis des Pferdes ist nicht immer chronisch, aber schwierige Fälle sind manchmal mühsam zu kontrollieren. Der IDT könnte helfen, um die ASIT zu formulieren und kann bei Management Veränderungen hilfreich sein.

要約

背景 – 馬のアレルギー性掻痒症および蕁麻疹は、獣医師および飼い主にとって難題であり、長期的な管理についてはほとんど知られていない。

目的 – 本研究の目的は、皮内アレルギー検査(IDT)結果を要約し、所有者の皮膚病への認識及び経時的なアトピー馬における治療および管理変更の効果を評価することである。

被験動物 – 2006年から2011年にイギリス南東部でアトピー性皮膚炎を発症した82頭の馬。

方法および材料 – 皮内アレルギー検査(IDT)結果を回顧的にレビューした。所有者は、皮膚の変化、投薬、アレルギー特異的免疫療法(ASIT)の効果および管理に関する電話アンケートに回答した。

結果 – 皮内アレルギー検査(IDT)から平均5.9年(28-88カ月)の経過を有する61人の所有者(74.4%)に接触することができた。そのうち3人は登録できなかった。残りの58頭のうち、所有者インタビュー時に死亡していた馬は11頭(19%)で、制御不能な皮膚疾患により安楽死した4頭(6.9%)の馬を含んだ。残りの47人の所有者は、皮膚疾患の兆候が18頭の馬(38.3%)で少なくとも2年間は見られていないことを報告し、既知のトリガーにより発症した2頭を含んだ。29頭の馬(61.7%)は依然として皮膚疾患をコントロールするために投薬を必要としたが、試験後25頭(53.2%)は投薬量が減少した。所有者は、アレルギー特異的免疫療法(ASIT)により14頭中9頭(64.3%)で、グルココルチコイドにより35頭中33頭(94.3%)および抗ヒスタミン剤により28頭中17頭(60.7%)で有益性を報告した。特定の管理変更を22頭に対し実施し、22頭中9頭(40.9%)で有益であると報告した。

結論 – 馬のアトピー性皮膚炎は必ずしも慢性であるとは限らないが、重症症例ではコントロールが困難である。皮内アレルギー検査(IDT)はアレルギー特異的免疫療法(ASIT)を策定するのに役立ち、管理変更のガイドに役立つ可能性がある。

摘要 – **背景** – 馬の過敏性掻痒和蕁麻疹对兽医和主人来说具有挑战性,人们对其长期管理知之甚少。**目的** – 总结皮内过敏原测试结果(IDT),并评估饲主对皮肤病的看法,以及随时间推移,其异位性马的治疗和管理改变。**动物** – 从2006年至2011年,英格兰东南部82匹异位性皮炎患马。**材料和方法** – 回顾性分析IDT结果,由主人完成关于皮肤变化、药物治疗、过敏原特异性免疫治疗(ASIT)的效果和管理的电话问卷。**结果** – 在IDT之后的平均5.9年时间(范围28-88个月),联系到61位饲主(74.4%),其中3人无法参与。在剩下的58匹马中,有11匹(19%)在联系主人时已经死亡,其中4匹(6.9%)因无法控制的皮肤病而被安乐死。其余47名主人报告发现,18匹马(38.3%)至少有两年没有出现皮肤病症状,其中仅有2匹找到了发病原因;29匹马(61.7%)仍然需要药物来控制皮肤病,尽管25只(53.2%)自测试以来药量较少。据饲主报告,接受ASIT治疗的14匹马(64.3%)中有9匹有效,糖皮质激素对35匹马中的33匹(94.3%)有效,抗组胺药对28匹马中的17匹(60.7%)有效。对22匹马实施特异性的管理改变,22匹中有9匹(40.9%)报告有效。**结论** – 马异位性皮炎不一定是慢性的,但严重的病例似乎难以控制。IDT可能有助于制定ASIT,并可以帮助指导管理改变。

Resumo

Contexto – O prurido alérgico e a urticária nos cavalos são desafiantes para os veterinários e proprietários; pouco se sabe sobre o seu manejo a longo prazo.

Objetivos – Sintetizar os resultados dos testes alérgicos intradérmicos (IDT), e avaliar as percepções dos proprietários a respeito das doenças cutâneas e os efeitos do tratamento e das alterações de manejo nos seus cavalos atópicos ao longo do tempo.

Animais – Oitenta e dois cavalos com dermatite atópica no sudeste da Inglaterra entre 2006 e 2011.

Métodos e materiais – Os resultados de IDT foram revisados retrospectivamente. Os proprietários completaram questionários telefônicos sobre as alterações cutâneas, medicações, efeitos da imunoterapia alérgeno-específica (ASIT) e manejo.

Resultados – Obteve-se contato com sessenta e um proprietários (74,4%) em média 5,9 anos (intervalo de 28-88 meses) depois da realização do IDT; destes proprietários, três não puderam ser incluídos. Dos 58 cavalos remanescentes, 11 (19%) já haviam falecido no momento da entrevista com os proprietários, incluindo quatro (6,9%) eutanasiados devido a doença cutânea incontrolável. Os outros 47 proprietários relataram que os sinais de doença cutânea não vinham sendo observados por ao menos dois anos em 18 cavalos (38,3%), incluindo dois que apresentaram apenas crises após exposição a fatores desencadeadores conhecidos. Vinte e nove cavalos (61,7%) ainda necessitavam de medicamentos para o controle da doença cutânea, contudo, 25 (53,2%) necessitavam de menor quantidade desde o teste. Os proprietários observaram benefícios com o uso de ASIT em nove de 14 cavalos (64,3%), com o uso de glicocorticoides em 33 de 35 animais (94,3%) e com o uso de anti-histamínicos em 17 de 28 cavalos (60,7%). Alterações específicas de manejo foram implementadas para 22 cavalos e foram relatadas como benéficas em nove de 22 animais (40,9%).

Conclusões – A dermatite atópica equina pode não ser sempre crônica, mas os casos graves são aparentemente de difícil controle. O IDT pode auxiliar na formulação de ASIT e guiar alterações de manejo.

Supporting Information

Table S1 Allergen solutions and dilutions used for intradermal testing of horses during the study period

	Allergen	Dilutions Greer from 20,000 PNU stock solutions up to 2008	Dilutions Greer from 20,000 PNU stock solutions from 2008	Dilution Artu
Controls	Histamine phosphate	1:10,000 w/v	1:10,000 w/v	0.1 mg/ml
	Saline	n/a	n/a	n/a
Indoor allergens and dusts	<i>Dermatophagoides farina</i> (farina mite)	1:10	1:10	100 NU/ml
	<i>D. pteronyssinus</i> (house dust mite)	1:1,000 w/v	1:1,000 w/v	100 NU/ml
	<i>Acarus siro</i> (flour mite)	1:20	1:20	100 NU/ml
	<i>Tyrophagus putrescentiae</i> (copra mite)	1:20	1:20	100 NU/ml
	<i>Lepidoglyphus destructor</i> (hay mite)	1:20	1:20	100 NU/ml
	<i>Euroglyphus maynai</i>	n/i	n/i	100 NU/ml
	House dust	1:20	n/i	n/i
	Grain mill dust	1:20	1:20	n/i
	Grain mill smut	1:1,000 w/v	1:1,000 w/v	n/i
Epithelia	Horse dander	n/i	1:20	n/i
	Dog epithelium	n/i		100 µg/ml
	Mouse dander	n/i	1:20	
	Cat dander (<i>Felis domesticus</i>)	1:20	1:20	100 µg/ml
	Mixed feathers (chicken, goose, duck)	1:20	1:20	
	Duck feathers (<i>Anas platyrhynca</i>)	n/i	n/i	100 µg/ml
	Goose feathers (<i>Anas anser</i>)	n/i	n/i	100 µg/ml
	Chicken feathers (<i>Pullus gallinaceus</i>)	n/i	n/i	100 µg/ml
	Sheep epithelia	1:20	1:20	
	Epithelial mix 1 (guinea pig, dog, cat, hamster, rabbit)	n/i	n/i	100 µg/ml
Grass pollens	Kentucky blue (meadow) grass (<i>Poa pratensis</i>)	1:20	1:20	1000 NU/ml
	Red top (bent grass, <i>Agrotis gigantean</i>)	1:20	1:20	1000 NU/ml
	Couch grass	1:20	1:20	n/i
	Orchard grass (cocksfoot, <i>Dactylis glomerata</i>)	1:20	1:20	1000 NU/ml
	Sweet vernal (<i>Anthoxanthum odoratum</i>)	1:20	1:20	1000 NU/ml
	Velvet grass (Yorkshire fog, <i>Holcus lanatus</i>)	1:20	1:20	1000 NU/ml
	Timothy (<i>Phleum pratense</i>)	1:20	1:20	1000 NU/ml
	Meadow fescue (<i>Festuca pratensis</i>)	1:20	1:20	1000 NU/ml
	Perennial rye grass (<i>Lolium perenne</i>)	1:20	1:20	1000 NU/ml
	Couch grass	1:20	1:20	n/i
	Brome grass	1:20	n/i	n/i
	<i>Avena sativa</i> (cultivated oat)	n/i	n/i	1000 NU/ml
	Bermuda grass (<i>Cynodon dactylon</i>)	n/i	n/i	1000 NU/ml
	Grass pollen mixture (Bermuda, orchard, sweet vernal, Timothy, velvet)	n/i	n/i	1000 NU/ml
Weed pollens	Sheep sorrel (<i>Rumex acetosella</i>)	1:20	1:20	1000 NU/ml
	Ragweed (<i>Ambrosia elatior</i>)	n/i	1:20	1000 NU/ml
	Golden rod (<i>Solidago virgaurea</i>)	n/i	1:20	1000 NU/ml
	Yellow dock (<i>Rumex crispus</i>)	1:20	1:20	n/i

	Common dandelion (<i>Taraxacum officinale</i>)	1:20	1:20	1000 NU/ml
	Red clover (<i>Trifolium pratense</i>)	1:20	1:20	1000 NU/ml
	Common mugwort (<i>Artemisia vulgaris</i>)	1:20	1:20	1000 NU/ml
	Daisy (<i>Leucanthemum vulgare</i>)	1:20	1:20	1000 NU/ml
	Stinging nettle (<i>Urtica dioica</i>)	1:20	1:20	
	English plantain (<i>Plantago lanceolata</i>)	1:20	1:20	1000 NU/ml
	Lamb's quarter (<i>Chenopodium album</i>)	1:20	1:20	1000 NU/ml
	Weed pollen mixture 1 (mugwort and nettle)	n/i	n/i	1000 NU/ml
	Weed pollen mixture 2 (mugwort, nettle, dandelion, plantain)	n/i	n/i	1000 NU/ml
Tree pollens	Alder (<i>Sambucus nigra</i>)	n/i	1:20	1000 NU/ml
	American elm	n/i	1:20	n/i
	Red oak	1:20	1:20	n/i
	Black/pussy willow (<i>Salix viminalis</i>)	n/i	1:20	n/i
	American beech (<i>Fagus sylvatica</i>)	1:20	1:20	1000 NU/ml
	Eastern sycamore (<i>Plantanus occidentalis</i>)	1:20	1:20	1000 NU/ml
	White poplar	1:20	1:20	n/i
	White ash	1:20	1:20	n/i
	American hazelnut (<i>Corylus avellana</i>)	n/i	1:20	1000 NU/ml
	White birch (<i>Betula pendula</i>)	1:20	1:20	1000 NU/ml
	Horse chestnut (Buckeye, <i>Aesculus hippocastanum</i>)	n/i	n/i	1000 NU/ml
	Hawthorn (<i>Crataegus</i>)	n/i	n/i	1000 NU/ml
	Linden (<i>Tilia cordata</i>)	n/i	n/i	1000 NU/ml
	Tree pollen mix 1 (birch, alder, hazel)	n/i	n/i	1000 NU/ml
	Tree pollen mix 2 (English oak, European beech, American elm)	n/i	n/i	1000 NU/ml
Moulds & fungi	<i>Aspergillus fumigatus</i>	1:20	1:20	n/i
	<i>Aureobasidium pullulans</i>	1:20	1:20	n/i
	<i>Alternaria alternata</i>	1:20	1:20	n/i
	<i>Phoma beta</i>	1:20	1:20	n/i
	<i>Penicillium notatum</i>	1:20	1:20	n/i
	<i>Cladosporium herbarium</i>	1:20	1:20	n/i
	<i>Fusarium moniliforme</i>	1:20	1:20	n/i
	<i>Mucor racemosus</i>	1:20	1:20	n/i
	<i>Rhizopus nigricans</i>	1:20	1:20	n/i
	<i>Trichoderma</i> spp.	1:20	1:20	n/i
	<i>Malassezia pachydermatis</i>	1:20	1:20	n/i
	Fungus mixture 1 (<i>Alternaria alternata</i> , <i>Aspergillus fumigatus</i> , <i>Cladosporium herbarum</i>)	n/i	n/i	100 ng/ml
Insects	Flea (<i>Ctenocephalides</i> spp.)	1:1,000 w/v	1:10	1000 NU/ml
	German Cockroach	n/i	1:20	n/i
	Horse fly (<i>Tabanus</i> spp.)	1:20	1:20	n/i
	Moth	1:40	1:40	n/i
	<i>Aedes communis</i> (mosquito)	1:20	1:20	n/i
	<i>Culicoides</i> (midge)	1:5	1:5	n/i
	<i>Culicoides</i> (midge)	1:10	1:10	n/i
	House fly	1:20	n/i	n/i
	Black ant	1:20	n/i	n/i

n/i not included. NU nitrogen unit

Table S2 Suggestions on management changes provided to horse owners to reduce exposure to environmental mites in atopic horses

Stable	Foodstuff	Rugs	Other
Replace loose bedding with rubber matting	Storage in clean, sealed containers	Avoid excessive rugging	Maintain horse at pasture for extended periods
Quarterly vacuuming and pressure hosing of stable walls, ceiling, floor	Replace hay with wilted, vacuum-packed grass products	Launder rugs frequently at high temperatures or freeze for 2-3 days after laundry	Use of broad-leaf weed-killer
Reduce exposure to birds and poultry (remove nests before eggs are laid)	Replace loose with cubed concentrate	Add human anti-allergy duvets (in polycotton cover) between skin and rugs to provide a barrier to dust mite allergens	Insect prophylaxis with frequent applications of permethrin-containing products as per data sheet or manufacturer's recommendations

Owners were informed that recommendations were based on anecdote rather than evidence for efficacy and that measures should be tailored to each horse depending on practicality and intradermal test result.