

Treatment of dermatophytosis in dogs and cats: review of published studies

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Abstract The recent literature on the treatment of dermatophytosis in dogs and cats was reviewed. Based upon *in vitro* studies using isolated infected hairs and controlled or field *in vivo* studies, the following topical treatments were consistently found to be antifungal (i.e. antidermatophyte): lime sulfur (1:16), 0.2% enilconazole rinses, and a combined 2% miconazole/chlorhexidine shampoo. Animals or hairs were either bathed or rinsed once or twice weekly. Itraconazole, griseofulvin and terbinafine were evaluated in controlled or field studies, most commonly involving cats. Griseofulvin (50 mg kg⁻¹) was reported to cure infected animals in 41–70 days. Itraconazole (10 mg kg⁻¹ once daily or in a combined daily/pulse therapy 10 mg kg⁻¹ once daily for 28 days and then week on/week off) was reported to cure infected animals in 56–70 days. Low-dose itraconazole (1.5–3.0 mg kg⁻¹) in 15-day cycles required 1–3 cycles (15–45 days). Various doses of terbinafine (5–40 mg kg⁻¹) were reportedly used to treat dogs or cats. The higher doses of terbinafine (> 20 mg kg⁻¹) were required to achieve a mycological cure; the number of treatment days to cure varied from 21 to > 126 days. Lufenuron was reported anecdotally to be an effective cure, however, this was not substantiated in controlled studies. Finally, fungal vaccines were not found to be effective against challenge exposure, however, there is evidence that they may be useful in treatment protocols.

Keywords: antifungal, cat, dermatophytosis, disinfectant, dog, lufenuron, *Microsporum*, treatment, *Trichophyton*, vaccine.

INTRODUCTION

Dermatophytosis is a superficial infection of the keratinized tissues including nails/claws, hair and stratum corneum of the skin. The fungi that cause these infections are known as dermatophytes. There are three genera that comprise the dermatophytes: *Microsporum*, *Epidermophyton* and *Trichophyton*. *Microsporum* and *Trichophyton* spp. are usually separated on the basis of host preference and natural habitat.¹ Anthropophilic species infect people and, less commonly, animals. Zoophilic species are usually animal pathogens but are capable of infecting people. Geophilic species inhabit the soil and serve as a source of infection for both animals and people. The purpose of this article is to briefly review the key clinical aspects of the disease and summarize recent studies on treatment options.

OVERVIEW OF THE DISEASE

Aetiology and pathogenesis

Over 20 different species of dermatophytes have been reported to cause clinical disease in dogs and/or cats.^{2,3}

However the most commonly isolated pathogens are *Microsporum canis*, *M. gypseum* and *Trichophyton mentagrophytes*. Infection occurs via direct transmission of infective spores to a susceptible host. Reservoirs of infection for both people and animals include contaminated environments and objects, animals with sub-clinical or clinical infections, and animals that are mechanical carriers of the spores on their hair coat.

Disease prevalence is unknown as this is not a reportable disease in most countries in the world. It has been estimated that dermatophytosis accounts for ≈ 2% of all skin infections;² however, prevalence of the disease tends to be more common in warm tropical/subtropical climates and/or where there are large numbers of feral animals.⁴

Any age, sex, or breed of animal is susceptible to infection. However, the disease tends to be more common in young, sick, debilitated and old animals. The presence of other diseases may also affect susceptibility to infection; dermatophytosis is three times more prevalent in cats with feline immunodeficiency virus than in uninfected cats.⁵ There is a strong clinical impression that longhaired animals are more susceptible to infection. This may be due to hereditary factors and/or the simple fact that long hairs trap spores and are a 'fungus friendly' environment. Studies with experimental models of dermatophyte infections have reported difficulties in the establishment of infection when cats were allowed to groom.⁶ It is possible that grooming may be an under recognized host defence mechanism.

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Mere exposure to dermatophyte spores does not guarantee infection. An unknown but 'critical mass' of spores must come into contact with a susceptible host. The spores must evade host defence mechanisms that include mechanical removal, competition with normal bacterial and fungal flora, exposure to fungistatic properties of epidermal lipids, low humidity of the skin surface and acquired host immunity.⁷ Factors that favour infection include any pre-existing disease that will cause an increase in surface humidity, cause micro-trauma to the skin and/or compromise host immune surveillance.⁷ Once a nidus of infection has been established, the fungal species proceeds to invade the keratin of hairs and skin and establish an infection. Recovery from infection is dependent upon a competent cell-mediated immune response.⁷

Clinical features

Dermatophytosis in dogs and cats is primarily a follicular disease and clinical signs are essentially a reflection of hair follicle damage and subsequent inflammation. Pruritus may vary from none to severe.

In dogs, lesions may consist of any combination of papules, pustules, focal to wide spread areas of alopecia, variable erythema, and variable scaling and crusting.^{2,3} Kerion reactions (nodular lesions), particularly on the face, may mimic areas of deep pyoderma and/or furunculosis or even autoimmune skin diseases.² These reactions are common in *M. gypseum* and *Trichophyton* spp. infections. Involvement of foot-pads, nails, and unguis folds may occur alone, or in combination with lesions on the trunk. Onychomycosis may lead to chronic nail fragility and deformity. Dermatophytosis is less common in dogs than in cats. It is often over-diagnosed; it is common for superficial pyoderma to be misdiagnosed as dermatophytosis. Dermatophytosis, demodicosis and bacterial pyoderma can be clinically indistinguishable in dogs.

In cats, lesions may consist of any combination of scaling and crusting with or without alopecia; focal, multifocal or generalized alopecia; erythema; miliary dermatitis and onychomycosis.^{2,3} Dermatophytosis is one of the few skin diseases of cats in which hyperpigmentation may be seen.^{2,4} Focal pruritic lesions mimicking areas of eosinophilic plaques may be seen. Longhaired cats may present with breakage and the complaint of 'excessive shedding'. Ingestion of larger than normal amounts of hair may result in owner complaints of constipation, weight loss, anorexia and vomiting; in the author's experience these are more common in longhaired cats. Cats may also develop granulomatous lesions (kerions, mycetomas, pseudomycetomas) of the skin and subcutaneous tissues. This is a rare clinical presentation with a poor prognosis for cure.

Diagnostic methods

Diagnostic methods associated with dermatophytosis have been reviewed in detail elsewhere.⁸ Wood's lamp examination looks for fluorescence on the hair shafts of *M. canis*-infected hairs. This examination is a

screening tool and is helpful for identification of hairs for direct examination and/or culture; a negative test does not rule out infection. Direct examination of hairs and scales looks for the presence of fungal hyphae and/or ectothrix spores. This procedure can be done with mineral oil, but is facilitated by the use of clearing agents such as potassium hydroxide 10 or 20%, 0.5% calcofluor white, or chlorphenolac. Definitive diagnosis can be made via skin biopsy, but it is not as sensitive as a fungal culture. Skin biopsy is helpful in the diagnosis of kerion reactions and granulomatous infections because cultures are often negative.² Histological examination of shaved, clipped or surgically removed samples of claws may be the test of choice in cases of fungal paronychia, onychorrhexis or onychomadesis.² Fungal culture is considered the 'gold standard' for diagnosis and can be accomplished via toothbrushing the hair coat and embedding the bristles in fungal culture plates or via plucking hairs for culture.^{2,3,8} Toothbrush fungal culturing is favoured in the US, where as in UK Denman brushes are used and in France carpet squares are preferred. The basic theory is similar; a sterile object that is likely to trap spores is mechanically brushed over the coat. The two most commonly used fungal culture media include Sabouraud's dextrose agar and dermatophyte test medium. Recently, a study was published that showed that increased incubation temperature (24–27 °C) resulted in a more rapid colour change on a commercial dermatophyte test media (DTM) developed for animals (Rapid Vet D, dms Laboratories, Inc. Flemington, NJ, USA) and improved sporulation of fungi in that study.⁹ This study also suggested that incubation at room temperature might account for false negative culture results.

In the early 1900's when many dermatophyte species were first being described, it was not recognized that strains transmitted from animals might change considerably after several host-to-host transfers. As a result of these transfers, a species may lose its typical morphology. This resulted in the description of a large number of species and variants of dermatophytes, especially within the *Microsporum* genus. With the advent of molecular technology, it has been possible to compare the molecular and conventional taxonomy of dermatophyte species.¹⁰ In a recent study, morphological and physiological features of various species and strains of the genus *Microsporum* were compared with the results of molecular testing and DNA sequencing resulting in seven species being reclassified or synonymized with *M. canis*, *M. ferrugineum* and *M. audouinii*.¹¹ As this technology becomes more widespread, the microbiological community will undoubtedly reclassify or rename many dermatophyte species or strains. The application of molecular technology has not been limited to the reclassification of organisms. Polymerase chain reaction-based assays and chitin synthase 1 (*Chs 1*) assays have been developed that can reliably identify dermatophyte infections in the skin and tissue.^{12–14} Although these tests will not likely replace conventional testing, their value will be in

the identification of infections or strains in clinical situations where typical morphological characteristics are not present and/or in tissue specimens.

REVIEW OF DRUG TREATMENT STUDIES

Unless otherwise stated, the reader should assume that *M. canis* is the pathogen being discussed.

Topical antifungal treatments

Topical antifungal treatments for dermatophytosis have been evaluated both *in vitro* using isolated infected hairs and in various *in vivo* studies.^{4,15–26} Currently, topical treatments are recommended as adjuvant to systemic therapy.^{2–4}

In vitro studies using isolated infected hairs or spores

There are five reports of studies using isolated infected hairs or spores to evaluate topical antifungal therapies and one using an agar dilution method,^{4,15–19} four of these also reported on topical compounds used as both on-animal and environmental treatments.^{15–18} The advantages of isolated infected hairs or spores for testing include removal difficulties encountered when trying to treat live animals, insurance of appropriate contact with the antifungal agent, and elimination of the problem of continued spore production on the host. Problems with this model include an inability to quantify and standardize the amount of infective material being tested, maceration of hairs causing the release of spores within hairs leading that can result in negative fungal cultures becoming 'positive' after repeated soakings, and loss of material from stockinnettes or other testing containers. Nevertheless, this technique has provided valuable information on the efficacy of various commonly used antifungal compounds and this testing method is a useful screening tool for potential commercial products.

Lime sulfur (1:16) and enilconazole have been shown to be consistently effective against *M. canis* in isolated infective spore models.^{4,16–18} Miconazole shampoo was evaluated in two studies. In one it was tested as a sole agent using isolated infective spores and in the second it was tested combination with chlorhexidine using an agar dilution technique in another.^{4,19} In both studies, miconazole was found to be an effective antifungal agent.

Captan, chlorhexidine (as a single agent), and povidine iodine have been consistently ineffective antifungal agents when tested using isolated infective spores and/or hairs.^{4,15–18} Sodium hypochlorite has shown mixed results when used at a dilution of 1:10;^{4,15–18} however, this product is not licensed nor recommended as an on-animal treatment and is more appropriately used as a disinfectant (see below).

In vivo topical therapy studies

There are seven published studies on the efficacy of topical antifungal therapy in cats; five of these studies

involved Persian cats.^{20–26} Chlorhexidine solution used as dip was evaluated as a sole topical therapy in a controlled study using an experimental *M. canis* infection model.²⁵ In that study, infected cats were dipped twice weekly for 150 days after the hair coat was clipped. At the end of therapy there was no significant difference between the chlorhexidine treatment group and the controls. Chlorhexidine was found to be ineffective.

In two studies, enilconazole was evaluated as a sole topical therapy (post whole body clipping) for the treatment of naturally occurring *M. canis* infection in Persian cats.^{23,24} In one study, cats were either dipped in 0.2% enilconazole ($n = 10$) twice weekly or in lukewarm water ($n = 4$) for 8 weeks.²³ In the enilconazole-treated cats, fungal cultures were culture negative as early as 5 weeks post initiation of therapy and remained negative to the end of the 10-week monitoring period. In contrast, 3/4 control cats were still culture positive at end of 10 weeks of monitoring; previous studies have shown that dermatophytosis is a self-limiting disease with cats self-curing somewhere between 12 and 17 weeks post infection.²⁵ In the second study, 22 Persian cats in a cattery were treated with 0.2% enilconazole every 3 days for a total of eight applications.²⁴ All of the cats improved clinically and were culture negative by day 28 of therapy. In both studies, cats were observed for adverse effects and serum chemistry panels were monitored. Enilconazole was well tolerated but may have been associated with hypersalivation, anorexia, weight loss, emesis, idiopathic muscle weakness and slightly elevated serum alanine aminotransferase (ALT) concentrations.

In three additional studies, topical therapy was evaluated but in combination with systemic therapy (lufenuron or griseofulvin).^{20–22,26} In one study, 14 Persian cats with naturally occurring dermatophytosis were treated with griseofulvin alone ($n = 7$) or with griseofulvin and concurrent twice-weekly shampoo ($n = 7$) with a combined 2% miconazole/2% chlorhexidine product.²⁰ Cats were not clipped prior to therapy in this study. At the end of the study, the lesion scores in the group receiving concurrent topical therapy decreased significantly more quickly than in the group receiving systemic therapy alone. The investigators reported no statistically significant difference between the two groups with respect to time to mycological cure; all treated cats were 'cured'. They concluded that topical concurrent therapy was beneficial and that, based upon the results of this study, clipping of the hair coat is not always necessary. The authors admit that results from this study are hard to interpret. The investigators report that at the end of the study 'none of the cats in either group was positive for *M. canis*'; however, they also report that four cats from one group and two from the other had positive coat cultures suggestive of 'contamination' (not defined). Environmental contamination and owner compliance were complicating factors.

In the second study, four groups of cats from a cattery with naturally occurring dermatophytosis were treated with oral griseofulvin and one of four concurrent

topical treatments twice weekly: water (placebo), 2% miconazole, 2% chlorhexidine, 2% miconazole and chlorhexidine.²¹ The investigators found that the combination shampoo was superior to the miconazole shampoo alone; cats receiving twice weekly shampoos and griseofulvin began showing negative cultures as early as 2 weeks after starting therapy. Miconazole shampoo was superior to chlorhexidine; chlorhexidine alone was no better than placebo; cultures did not start becoming culture negative until 4 weeks after starting therapy.

In the third study, 100 Persian and other breed cats from two different catteries with naturally occurring dermatophytosis were divided into two groups.²² The first group ($n = 36$) was treated concurrently with once weekly topical 0.2% enilconazole rinses for 4 weeks and twice-daily micro-sized griseofulvin (25 mg kg^{-1} for 5 weeks). The second group of cats ($n = 64$) was treated concurrently with once weekly topical 0.2% enilconazole rinses for 4 weeks and with two oral doses of lufenuron (60 mg kg^{-1} at day 0 and 30). None of the cats in this study were clipped prior to, or during, therapy. In both catteries and in both groups, the mean number of fungal colonies decreased rapidly in the first 15 days of therapy, remained stable for the next 45 days, and then increased from day 60 until the end of therapy (day 90).²² No cures were reported in this study in either group or cattery. This study was complicated by heavy environmental contamination in the face of efforts to disinfectant the environment; it is impossible to know if positive cultures post day 60 represented infection or mechanical carriage.

In the fourth study, 21 cats experimentally infected with *M. canis* were divided into three groups: control, systemic therapy alone and systemic therapy combined with twice weekly topical therapy with a 2% miconazole/2% chlorhexidine shampoo.²⁶ The investigators did not report clipping the cats prior to treatment. In this study, cats treated with both griseofulvin and twice weekly miconazole/chlorhexidine shampoo showed a significantly faster mycological and clinical cure than in cats treated with just griseofulvin alone. Cats receiving combined therapy were cured at the end of 9 weeks of therapy compared with 11 and 12 weeks for single agent and control groups, respectively.

Systemic antifungal treatment

There are 17 studies that report on the efficacy of griseofulvin, itraconazole, terbinafine, or lufenuron alone or in combination with other therapies.^{20–22,26–39}

Griseofulvin. Griseofulvin is a fungistatic antifungal agent that inhibits nucleic acid synthesis and cell mitosis metaphase by interfering with the function of spindle microtubules.⁴⁰ Griseofulvin was evaluated in several studies;^{20–22,26,29} four studies identified treatment groups where it was used as a sole therapy as at a dose of 50 mg kg^{-1} .^{20,26,29,39} Mycological cure was solidly achieved in two of these studies in 63–70 days for cats. In the study by Balda *et al.*³⁹ the mean treatment

time was 41 days for 9 dogs and 3 cats with 100% of animals treated being cured. In the fourth study, the authors reported that the cats were considered 'cured' but indicated that small numbers of *M. canis* colonies consistent with coat contamination were isolated from 4 of 7 making it unclear how to evaluate these results.²⁰ In four studies, griseofulvin was evaluated in conjunction with topical therapies (enilconazole, miconazole, chlorhexidine or 2% miconazole/chlorhexidine shampoo)^{21–22,26} or lufenuron.²² Again the total daily dose was 50 mg kg^{-1} . When combined with enilconazole or lufenuron, mycological cure was not reported in any of the cats after 5 weeks of therapy.²² However, it is important to note that 46 of the cats were Persians and none of the 100 cats in the study was clipped prior to therapy; the investigators noted marked environmental contamination. In the second study, unclipped Persian cats were also the focus; the authors reported a cure at the end of 70 days of griseofulvin and shampoo therapy, but as mentioned previously two cats had '*M. canis* coat contamination' making it difficult to draw conclusions. In one, griseofulvin was combined with 2% miconazole/2% chlorhexidine twice-weekly shampoo therapy. Cats were reported as mycologically cured at the end of 42 days.²⁶ In the last study, griseofulvin therapy was combined with twice weekly shampoos with either chlorhexidine, miconazole or a combined shampoo.²¹ The authors reported an improvement in all groups; however, the combined group 'was superior' to the other groups with this group showing negative cultures after 4 weeks of therapy.²¹

Itraconazole. Itraconazole is triazole derivative that works by altering fungal cell membrane permeability through inhibition of ergosterol synthesis.⁴¹ At low doses it is fungistatic and at higher doses fungicidal. Itraconazole's antifungal activity against *M. canis* infection in cats has been reported in three studies all of which were different.^{27–29} In first study, five cats with an experimental infection received 10 mg kg^{-1} once daily and were reported to be mycologically cured after 56 days.²⁹ In the second study, 15 cats with naturally occurring *M. canis* infections were treated with low-dose itraconazole ($1.5–3.0 \text{ mg kg}^{-1}$) for once daily for 15-day cycles of therapy.²⁸ Eight of 15 cats were cured. Six of eight cats required only one cycle of therapy, whereas the remaining two cats needed prolonged treatment (two 15-day cycles and three 15-day cycles). In the third study, nine cats with naturally occurring dermatophytosis were treated with itraconazole combined continuous/pulse therapy protocol.²⁷ All cats received itraconazole 10 mg kg^{-1} once daily for 28 days and then on 'week on/week off' basis. Eight of nine cats were considered cured after 56 days and one cat was cured after 70 days of therapy.

Terbinafine. Terbinafine is an allylamine antifungal agent that suppresses the biosynthesis of ergosterol via inhibition of the fungal enzyme squaline epoxidase. The drug is considered to be fungicidal against

dermatophytes.⁴² The use of terbinafine to treat feline *M. canis* dermatophytosis has been reported in four studies;^{30–34} two studies reported on different aspects of the same experimental infection.^{30,31} In one study, three groups of cats were experimentally infected with *M. canis* and monitored for 120 treatment days.^{30,31} In this experiment, two doses of terbinafine were compared with each other and an untreated control group. The investigators reported that there was no difference when low dose terbinafine (10–20 mg kg⁻¹) was compared with the untreated control group. The cats receiving high dose terbinafine (30–40 mg kg⁻¹) were considered cured after > 120 days (126 days) of therapy. In one of the studies, serum and hair concentrations of terbinafine were reported. There was no significant difference in plasma concentrations between the low and high doses of terbinafine; however, the high-dose terbinafine group had a significantly higher concentration of terbinafine in hair compared to the low dose.³¹ In a second study, 41 dogs and 24 cats were treated with terbinafine at a dose of 10–30 mg kg⁻¹ once daily.³² No adverse effects were noted and the mean length of therapy for mycological cure for dogs was 53 days (21–126) and 63 days (28–84 days) for cats. In the third study, 35 dogs or cats were treated with either griseofulvin (see above) or with one of two doses of terbinafine (5 mg kg⁻¹ and 20 mg kg⁻¹)³⁹ were used to treat dogs or cats with naturally occurring dermatophytosis. Terbinafine at either dose was effective in 81.3% of animals treated; animals responding to treatment required a mean of 33 days of therapy. In a fourth study, 15 cats with naturally occurring dermatophytosis were treated with terbinafine 30 mg kg⁻¹ once daily for 14 days; 12 cats completed the study.³⁴ Cats were followed for a total of 90 days and at the end of this time 11 of 12 cats were mycologically cured. None of the cats was culture negative at the end of 14 days of therapy. The first mycological cures were noted at day 60 days. In the last study, 9/20 laboratory cats were found to be culture positive for *M. canis*, but lesion free. All of the cats were treated with terbinafine 8.25 mg kg⁻¹ once daily for 21 days.³³ Cats were reported to be mycologically cured at end of monitoring, 63 days. All of these studies reported the drug to be well tolerated with vomiting as the only adverse effect.

Lufenuron. Lufenuron is a benzoylphenylurea drug that disrupts chitin synthesis and is used for flea control. Chitin is a critical component of the outer cell wall of fungi and it possible drugs that disrupt chitin synthesis might also have antifungal activity. The use of lufenuron in the treatment of dermatophytosis has been described in several studies.^{35–38,43} In 2000, a retrospective study suggested that lufenuron treatment was strongly associated with recovery in a large number of dogs and cats with a number of fungal infections, including dermatophyte infections.³⁵ In that report, dogs and cats received lufenuron at doses compatible with the manufacturer's recommended dose for routine flea control. In a follow-up study, the authors

reported a recommended drug dose of 80–100 mg kg⁻¹ once every two weeks until mycological cure.³⁶ The authors reported that the time to cure ranged from 6 to 37 days (mean 13.7 days) in dogs and cats with dermatophytosis. In a large retrospective survey conducted in Italy, veterinarians were asked about their clinical observations with lufenuron as a treatment dermatophytosis in mammals.⁴³ It is difficult to interpret the results of this study accurately as diagnosis of cases could include documented infection or suspected infection. Furthermore, criteria for 'cure' were equally variable; 'cure' could be defined as clinical resolution of signs or mycological cure. In cases where mycological cure was determined, the mean time to recovery was 34.7 days (range 12–90 days). There are two reports of controlled blinded studies evaluating the efficacy of lufenuron to prevent or alter the course of experimentally induced *M. canis* infections in cats.^{37,38} In one study, lufenuron was used as a pretreatment prior to challenge exposure and infection.³⁸ Two oral doses of lufenuron were evaluated (30 or 133 mg kg⁻¹); after 2 months of pretreatment the kittens were challenged with infective *M. canis* spores. In this study, neither dose of lufenuron prevented infection nor altered the course of infection; however, it is important to note that the challenge was markedly larger than what would occur under field exposure. In a follow-up study, two groups of cats were pretreated with either oral or injectable lufenuron prior to exposure to a subclinically infected cat.³⁷ Cats received four doses of lufenuron at monthly intervals prior to exposure to the infected cat and monthly treatments thereafter for an additional 5 months. In this study, lufenuron did not prevent infection in either treatment group. In addition, infections in the control and two treatment groups resolved at about the same time. What was noticed in this study was that infections were established more slowly in the lufenuron-treated groups when compared with the control group. In a final study involving 100 cats in two catteries with naturally occurring dermatophytosis, lufenuron was used in conjunction with topical enilconazole.²² Although the investigators reported a decrease in fungal culture counts over 90 days and clinical resolution of signs, cures were not reported.

Vaccine studies

There are three studies reporting on the use of fungal vaccines in cats to prevent dermatophytosis.^{44–47} In addition, a killed dermatophyte vaccine for treatment of *M. canis* in cats is available in the United States (Fel-O-Vax, MC-K, Fort Dodge Laboratories, Fort Dodge IO, USA). This product is licensed for use for the treatment and prevention of lesions, but not disease. In Russia, there is also a live attenuated vaccine for both treatment and prevention of small animal dermatophytosis; however, there is also limited information available on this vaccine.⁴⁷ In two of studies, an experimental killed cell-wall vaccine was evaluated first in a direct application challenge exposure model and then in a less intense cohabitant challenge model.^{44,45} In neither

study was the vaccine protective against challenge exposure. In a third study, an experimental combined live-inactivated dermatophyte vaccine and a killed commercially available dermatophyte vaccine (Fel-O-Vax) were evaluated for prophylactic immunity and any therapeutic benefit.⁴⁶ Neither vaccine prevented infection or provided a more rapid cure when compared with each other or untreated controls. However, vaccination was associated with a slightly reduced severity of initial infection when compared with controls. Interest in vaccination as a treatment or prophylaxis continues to be an area of intense interest, primarily because of success in farmed foxes.^{48,49}

CONCLUSIONS

Based upon the current information available for the treatment of dermatophytosis I have made the following treatment conclusions based upon my interpretation of the studies. Other clinicians may have differing interpretations.

Treatment endpoint

The endpoint of treatment in all studies was two or three negative consecutive fungal cultures obtained at weekly or bi-weekly intervals. This recommendation still stands.

Optimum treatment

The optimum treatment protocol for dogs or cats with dermatophytosis involves a combination of clipping of the hair coat, twice weekly topical antifungal therapy, concurrent systemic antifungal therapy and environmental decontamination. Fungal culture monitoring should be performed every 2–4 weeks until mycological cure.

Clipping of the hair coat

Although no controlled study exists that proves that clipping of the hair coat shortens the duration of infection, clinical studies strongly support the recommendation that cats with long hair and/or generalized dermatophytosis should be clipped. Although not necessary in all cases of dermatophytosis, clipping of the hair coat is optimum.

Topical antifungal therapy

In vitro and *in vivo* studies have documented that lime sulphur, enilconazole, and miconazole have consistent antifungal activity in the treatment of dermatophytosis. The most commonly recommended treatment schedule is twice weekly whole-body applications of one of these products. Lime sulfur and enilconazole should not be rinsed from the hair coat and a contact time of 10 min for miconazole shampoos is recommended for efficacy. Captan, chlorhexidine (as a single agent), and povidine iodine have been consistently ineffective antifungal agents when tested using isolated infective spores and/or hairs and are not recommended

for use. Topical therapy should be used in conjunction with systemic therapy; if cost constraints do not allow for concurrent systemic therapy, twice weekly applications of either lime sulphur or enilconazole can be used until a mycological cure (2–3 negative consecutive fungal cultures) are obtained.

Systemic antifungal therapy

Systemic antifungal therapy is the treatment of choice for dermatophytosis. Griseofulvin, itraconazole and terbinafine are all effective systematic antifungal agents.

Griseofulvin. Griseofulvin therapy is rapidly being replaced by itraconazole and terbinafine therapy but it is still an effective antifungal agent. The most commonly used dose regimen is daily

- micro size 50 mg kg⁻¹ orally every 24 h or divided every 12 h;
- ultramicro size 10–15 mg kg⁻¹ orally every 24 h or divided every 12 h.

Itraconazole. Based upon the studies reviewed, itraconazole therapy is flexible. The most commonly effective dose was 5–10 mg kg⁻¹ and the following dosing schedules are recommended as treatment options:

- daily dosing: itraconazole 5–10 mg kg⁻¹ orally every 24 h;
- combined continuous/pulse therapy: itraconazole 5–10 mg kg⁻¹ orally every 24 h for 28 days and then on an alternate week regimen (1 week off and 1 week on);
- cycle therapy: itraconazole 5–10 mg kg⁻¹ orally every 24 h for 15 days, followed by fungal cultures 10–15 days post treatment. These cycles are repeated until the cats are cured.

Terbinafine. Terbinafine is the newest systemic antifungal agent to be used in dogs and cats. This drug is well tolerated by cats and dogs. When this drug is used at 30–40 mg kg⁻¹ significantly higher concentrations of drug are found in hairs when compared to lower doses.

- Terbinafine 30–40 mg kg⁻¹ orally every 24 h.

It may be possible to use terbinafine (30–40 mg kg⁻¹ orally) as a substitute for itraconazole in continuous/pulse or cycle therapy.

Lufenuron

In placebo-controlled studies, lufenuron did not prevent or alter the course of infection. Controlled studies did document that cats receiving lufenuron had infections were established more slowly in the lufenuron-treated groups when compared with the control group, but a difference in treatment outcome was not noted. Whether this benefit justifies the cost of lufenuron therapy or can be 'manipulated' into a therapeutic advantage is not known. At this time, lufenuron therapy is

not recommended for the treatment or prevention of dermatophytosis.

Vaccine therapy

Interest in the development of a fungal vaccine for prevention and/or therapy of *M. canis* dermatophytosis continues to be the focus of a great deal of research. To date, neither experimental nor commercial vaccines have been shown to be protective against challenge exposure. Vaccination was associated with a slightly reduced severity of initial infection when compared with controls in cats. At this time, vaccination for *M. canis* is not recommended for prophylaxis, but may be beneficial as an adjuvant to conventional therapy.

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Résumé Une revue de la littérature récente sur le traitement des dermatophytoses chez le chien et le chat est présentée. En se basant sur des études *in vitro* portant sur des poils infectés et sur des études contrôlées ou de terrain *in vivo*, les traitements topiques suivants peuvent être considérés comme antifongiques (i.e. antidermatophyte): lime sulfur (1:16), lotion d'enilconazole à 0.2% et shampooing à 2% miconazole/chlorhexidine. Les animaux ou des poils étaient soit baignés soit rincés une ou deux fois par semaine. L'itraconazole, la griséofulvine et la terbinafine ont été évalués dans des essais contrôlés ou des essais terrain, la plupart du temps chez le chat. La griséofulvine (50 mg kg⁻¹) a permis une guérison des animaux infectés en 41 à 70 jours. L'itraconazole (10 mg kg⁻¹ une fois par jour ou en traitement pulsé 10 mg kg⁻¹ une fois par jour pendant 28 jours puis une semaine avec traitement, une semaine sans traitement) a permis de guérir les animaux infectés en 56 à 70 jours. L'utilisation de l'itraconazole à faible dose (1.5 à 3.0 mg kg⁻¹) pendant des cycles de 15 jours a nécessité 1 à 3 cycles (15 à 45 jours). Des doses variables de terbinafine ont été utilisées pour traiter des chiens ou des chats (5 mg kg⁻¹ à 40 mg kg⁻¹). Des doses élevées (>20 mg kg⁻¹) étaient nécessaires pour obtenir une guérison mycologique. Le nombre de jours de traitement variait de 21 à >126 days. Le lufenuron a également anecdotiquement été rapporté comme un traitement efficace bien que cet effet ne soit pas confirmé par des études contrôlées. Enfin, la vaccination antidermatophyte n'a pas prouvé son efficacité dans un modèle expérimental, bien qu'il existe des preuves qu'elle puisse être efficace comme traitement adjuvant.

Resumen Se revisó la literatura reciente sobre el tratamiento de la dermatofitosis en perros y gatos. Basándonos en estudios *in vitro* utilizando pelos infectados aislados y estudios controlados o de campo *in vivo*, los siguientes tratamientos tópicos fueron considerados antifúngicos (es decir, antidermatofitos): sulfuro de lima (1:16), 0.2% enjuagues con enilconazol, y un champú con una combinación de un 2% de miconazol/clorexidina. Los animales o los pelos fueron bañados o enjuagados una o dos veces a la semana. El itraconazol, la griséofulvina, y la terbinafina fueron evaluados en estudios de campo o estudios controlados, la mayoría implicando gatos. La griséofulvina (50 mg kg⁻¹) curó animales infectados en 41 a 70 días. Se ha publicado que el itraconazol (10 mg kg⁻¹ una vez al día o en una combinación de terapia diaria/intermitente a 10 mg kg⁻¹ una vez al día durante 28 días y después semana sí/semana no) cura los animales infectados en 56 a 70 días. El itraconazol a dosis bajas (1.5 a

3.0 mg kg⁻¹) en ciclos de 15 días requería de 1 a 3 ciclos (15 a 45 días). Se ha publicado el uso de varias dosis de terbinafina (5 mg kg⁻¹ a 40 mg kg⁻¹) para tratar perros y gatos. Las dosis más altas de terbinafina (>20 mg kg⁻¹) eran necesarias para conseguir una curación micológica; el número de días de tratamiento para conseguir la curación variaba de 21 a >126 días. Anecdóticamente se ha descrito que el lufenuron puede ser efectivo, aunque esto no pudo ser confirmado mediante estudios controlados. Finalmente, las vacunas fúngicas no fueron efectivas contra la exposición, aunque existen pruebas de que pueden ser útiles en protocolos de tratamiento.

Zusammenfassung Neue Veröffentlichungen über die Behandlung der Dermatophytose bei Hunden und Katzen werden besprochen. Basierend auf in vitro Studien mit isolierten infizierten Haaren und kontrollierten oder Feld-Studien in vivo erwiesen sich folgende topische Behandlungen übereinstimmend als antimykotisch (d.h. gegen Dermatophyten) wirksam: Schwefelkalk (1:16), 0,2% Enilkonazol Spülungen und ein Shampoo mit einer Kombination von 2%Miconazol/Chlohexidin. Tiere oder Haare wurden ein- bis zweimal wöchentlich gebadet oder gespült. Itraconazole, Griseofulvin, und Terbinafine wurden in kontrollierten oder Feld-Studien zumeist bei Katzen evaluiert. Griseofulvin (50 mg/kg) heilte infizierte Tiere innerhalb von 41 bis 70 Tagen. Itrakonazol (10mg/kg 1xtäglich oder in einer kombinierten Therapie mit täglicher Gabe und Pulstherapie mit 10mg/kg 1xtäglich über 28 Tage und dann alternierend mit und ohne Therapie im wöchentlichen Wechsel) heilt Tiere innerhalb von 56 bis 70 Tage. Niedrig dosiertes Itrakonazol (1,5 bis 3,0 mg/kg) in 15-tägigen Zyklen erforderte 1 bis 3 Zyklen (15 bis 45 Tage). Verschiedene Dosierungen von Terbinafine (5 bis 40mg/kg) wurden zur Behandlung von Hunden und Katzen eingesetzt. Es war die höhere Dosis von Terbinafine (>20mg/kg) nötig, um eine mykologische Heilung zu erzielen. Die Anzahl an Behandlungstagen variierte von 21 bis >126 Tage. Es wurde gelegentlich berichtet, dass Lufenuron erfolgreich zur Behandlung eingesetzt wurde, dies konnte durch kontrollierte Studien nicht untermauert werden. Zum Schluss erwiesen sich Pilz-Vakzine als nicht wirksam bei Belastungsexposition, es gibt jedoch Anzeichen, dass sie als Bestandteil von Behandlungsprotokollen nützlich sein könnten.