DERMATOPHYTOSIS: DECONTAMINATON RECOMMENDATIONS

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Dermatophytosis is the most common infectious and contagious skin disease of cats, especially kittens. All cats are susceptible, but the most at risk cats are those at the age extremes, cats with systemic illnesses that encounter another infected cat (e.g. the new kitten/cat), cats that suffer poor husbandry, and cats with chronic skin diseases that predispose them to self-trauma (e.g. chronically pruritic cat). It is not within the scope of this chapter to discussed details of diagnosis and treatment and the reader is referred to references for more details.[1,2] However, successful treatment involves concurrent use of systemic and topical therapy, reasonable confinement to easily cleaned areas, and decontamination of the environment. Much has been written about decontamination of the environment, however little is based upon actual controlled studies and/or field studies. Early controlled studies that lead to many of the author's previous recommendations for decontamination were conducted before the importance of hard cleaning was known.[3] The two major goals of this chapter are to summarize known facts about environmental contamination and to present evidence based information for best practices recommendations.

ENVIRONMENTAL CONTAMINATION

The Source of Environmental Contamination

A very common statement from clients when informed about the real possibility that environmental contamination is likely to occur is, *"You mean it's in my house!".* This is not an unreasonable comment given that most lay people are familiar only with mildew and media coverage of black mold (*Stachybotrys chartarum*), mold and sick building syndrome or mold contamination post flooding. It is important to make it explicitly clear to explain that *M. canis* requires keratin to grow and multiply and the home environment does not support its growth. The only source is from the infected cat. Naturally infective spores are called arthroconidia and are asexual spores formed by segmentation of existing hyphae. Their formation is a survival response to the depletion of nutrients or other environmental stressors.[4,5]

Disease Pathogenesis and Its Impact on Environmental Contamination

Recent studies on the pathogenesis of *M. canis* infection do highlight important information relative to environmental contamination. Briefly, active infection requires exposure of susceptible skin to an unknown critical mass of viable arthrospores. In order to establish and infection, the spores must first adhere to the stratum corneum . After successful adherence, infection progresses with penetration of corneocytes via fungalysins (proteases) followed by the emergence of germ tubes and spreading hyphae. In the case of *M. canis*, adhesion is time dependent starting with two hours post exposure and increasing up to six hours post exposure. [6,7] Studies using feline reconstructed epidermis exposed to *M. canis* spores, have shown that inoculation sites are culture positive and have fungal hyphae in the stratum corneum within five days post inoculation .[7] The clinically important take home points from these studies are 1) the incubation period from exposure to early infection sites are capable of shedding infective is days not weeks, 2) the time from first active infection to clinically obvious lesions is two to three weeks, and 3) environmental contamination starts to occur long before clinical signs are noted.

Why Decontaminate the Environment?

The most commonly cited reason for environmental decontamination is to prevent infection of people and susceptible animals via naturally infective material in the environment. [1,2] In people, a major mode of transmission of tinea pedis (*Trichophyton spp*) is through contact with contaminated objects (e.g. socks) or by walking barefoot in public areas such as showers or pool.[8] However, well documented cases of human infection with *M. canis* from casual contact with a contaminated environment are rare in the literature. One well documented case involved a five year old boy that contracted *M. canis* from the interior of a second hand car.[9] There was no known contact with an infected animal and investigation later found that child had contracted the infection from contact

with contaminated textiles in the car. The car's previous owner of the car had a dog with generalized *M. canis* dermatophytosis. There is little doubt that exposure to contaminated environments will result in cats being fungal culture positive for *M. canis* via mechanical carriage of spores on the hair coat. Given the fact that most cases of dermatophytosis are almost always traced to some contact with another infected animal, it is hard to provide clients with factual estimates of the risk of another cat in the home developing true disease from contact with naturally infective material.

A study on co-habitant infection development in a treatment study had some interesting findings regarding the risk of infection from the environment. In an experimental study evaluating the protective effect of a pretreatment with a compound, 24 specific pathogen juvenile cats housed in groups of eight cats per room were exposed to a single infected cat.[10] This cat had been experimentally infected with a strongly fluorescent strain of *M. canis* and allowed to self-cure until the clinical lesions had resolved and only Wood's lamp positive hairs remained in the pre-auricular area. Environmental and individual cat cultures were monitored weekly along with examination for the development of lesions using a Wood's lamp. All environments and cats became readily fungal culture positive shortly after introduction of the infected cat. However, infection site development was slow with lesions developing in a clear pattern. The most social cats became infected first with the shy cats infected last. The first place lesions developed was on cat to cat contact sites, i.e. the face and ears. If causal exposure to spores in the environment were a high risk factor for contracting disease, it is reasonable to postulate that infection should have developed in all of the 24 cats at the similarly, but it did not. In other studies with group housed cats, heavily contaminated environments never resulted in re-infection.[11-15] Contaminated fomites are a known source of inoculation of infective spores and subsequent lesion development, however the fomites invariably are items that not only deposit spores but also induce micro-trauma to the skin, i.e. clippers, brushes, gloved hands restraining cats. It is not inconceivable that a susceptible cat, especially a kitten or immunocompromised cat, could contract *M. canis* dermatophytosis solely from exposure to a contaminated environment, but this author believes it to be an uncommon source of infection. Excluding traumatic induction of lesions, one plausible scenario is a cat with an actively pruritic skin being exposed to a contaminated environment.

If *M. canis* infection in people almost always involves contact with an infected animal or an infected person and the environment is not a significant risk factor of infection for cats, then why the emphasis on environmental decontamination?[16] **The primary reason decontamination is necessary is that a contaminated environment will result in false positive fungal culture results which make it difficult, if not impossible, to determine mycological cure.** False positive cultures may result in unnecessary confinement which can be highly stressful for cats and/or interfere with the socialization of newly acquired cats or kittens, prolonged topical treatment of cats, and prolonged administration of systemic antifungal drugs. False positive fungal culture results also increase the total cost treatment of the infected cat. As will be detailed later in this chapter, research has shown that spores are more readily removed than what is currently believed. Environmental cleaning focusing on removal of spores to prevent false positive fungal cultures is equally adequate to protect susceptible people or animals from infection.

Spores in the Environment Are They Merely Viable or Truly Infective?

One of the earliest English language publications documenting the long term viability of *M. canis* spores was in 1960.[17] In this report, hairs from three different kittens with strongly fluorescing Wood's positive *M. canis* infected hairs were fungal cultured once weekly until there were six consecutive negative fungal cultures. The first negative cultures were noted at 6 to 9 months and the last positive fungal culture was reported at 10 to 14 months. The remaining hairs were unable to infect susceptible kittens in an experimental infection attempt. These findings were very similar to

those of another study where 25 specimens were periodically fungal cultured. The first negative fungal culture was found at 14 months and the last fungal positive culture was found at 18 months.[18] Very recently, this author found a cache of Wood's positive hairs in the laboratory that had been stored at room temperature in plastic vials. The oldest hairs were 21 years old. For pure academic interest every possible attempt was made to determine if there were any viable spores present; after several months of effort a single *M. canis* colony was isolated. A lay person reading this would conclude that *M. canis* spores live for over two decades in the environment.

This author's experience with thousands of hair and toothbrush specimens from cats over the last 25 years is that *some* isolates will remain culture positive for up to 24 months, but clearly not all.[19] What is more commonly observed in the author's laboratory is for isolates to lose viability and become culture negative with months of collection. For example, in a recent study the carpet culture technique was used to collect infective hairs and spores from Wood's positive culture positive cats.[20] Specimens were logged and cultured within days of collection using a cotton tip applicator to confirm culture status; all specimens had too many to count (TMTC) colonies per plate. However, within five months of collection 30% (45/150) of samples were culture negative including after inoculation by direct inoculation of the carpet surface onto the surface of a fungal culture plate. In addition another 10% of specimens had <10 colonies/carpet square.

In the author's experience with stored specimens, over time, the number of viable colonies that can be isolated from a sample markedly decreases-often within months, the number of days from inoculation to positive culture may be >21 days, laboratory manipulation (hydration, growth on enriched medium) commonly is needed to reach culture positive status and even then, and the number of colony forming units (cfu)/plate is often less than 10. In addition, these colonies often have abnormal gross colony characteristics, abnormal microscopic features and are poorly sporulating. Finally, the hair shaft is protective, i.e. the 21 year old viable arthrospore, but even arthrospores with hair shafts are very vulnerable to environmental conditions. For example, as the laboratory humidity increases spore viability decreases. Specimens from containers that are repeatedly opened and closed are less viable than those that are sampled less frequently.[19] If spores are removed from hair shafts as if is done in one testing model[21], spores remain viable for 1 week to 3 months if stored at 4°C, but at room temperature rarely survive for more than 1 week.[19]

It is indisputable that arthrospores, particularly those protected within hairs and debris, may remain viable for years. Any client search the literature will find this fact, however several important things need to be impressed upon clients. First, all of the studies citing 'culture positive status' are reporting viability of spores on fungal culture medium; it is unknown how infective these spores are under natural conditions. Second, all of these studies stored spores under laboratory conditions, not in homes with temperature and humidity fluctuations. Third, these studies are used infected hairs and the hair shafts protect spores. Simple mechanical removal of shed hairs removes the bulk of infective material and decreases risk. Fourth, spores not in hair shafts are vulnerable to mechanical cleaning and disinfectants. Finally, there is great variability in how long spores remain viable.

What are "Reasonable Confinement" and "An Easily Cleaned Room"?

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ENVIRONMENTAL SAMPLING

When to Obtain Environmental Samples

A common question from clients is "When do we sample the environment?" *In this author's opinion, the only time it is cost effective to sample the environment for contamination is when it is pertinent to the treatment plan.* Based upon environmental culturing of homes where infected cats are living, environmental contamination is an expected finding.[22,23] Contamination was most severe in homes where there were kittens; *M. canis* dermatophytosis is more common in kittens and often more

severe than in adults.[22] There is no reason to sample the environment to document that contamination is present at the time of diagnosis. The cat merely needs to be confined to an area(s) that are easily cleaned and any exposed areas (especially where there is visible cat hair) simply needs to be cleaned (see below). If a client has a strong reason to know for certain that a specific exposed areas is decontaminated, for example, a child's bedroom, then environmental sampling is indicated.

Environmental sampling is most often recommended when cats have been appropriately treated and the client has been compliant with reasonable confinement and cleaning, i.e. when false positive fungal cultures are suspected. The problem of false positive fungal cultures is most common when l cultures are not performed in house and results are being reported as 'positive' or 'negative'. In house fungal cultures allow one to determine the number of cfu/plate. If the cat is clinically cured, but fungal culture positive and there are one to 10 cfu/plate, environmental contamination is most probable. Clinically normal cats with an active sites infection, appropriately fungal cultured, have >10 cfu/plate even if the active infection site is limited to one whisker.

Cats that are culture positive due to fomite carriage, readily become culture negative within 48 to 72 hours after being removed the environment. Merely wiping the cat's coat with a damp towel to remove is not always effective in removing spores. The best way to mechanically remove spores is to let the cat groom itself in a clean environment. In the home, the cat is housed in unexposed room for 72 hours and then fungal cultured. Over the next 72 hours while the cat is living in a different room, the owner decontaminates the exposed rooms with two or three hard cleanings. The efficacy of decontamination is determined by two environmental fungal cultures. One fungal culture obtained from the floor and the other obtained from surfaces above the floor that the cat can reach. If the cat is culture negative, environmental contamination was the problem. If not, then the cat is infected and treatment change is needed. If the owner is appropriately compliant with cleaning, the environmental cultures should be negative. If environmental cultures are not negative, cleaning protocols need to be reviewed with the client and a search for the 'hot spot' of contamination identified.

Environmental Cultures of Non-Porous Surfaces

Institutional and industry environmental sampling is done with a specialized culture plate called a 'contact plate' that is pressed against the surface of the target area. This is not a practical method for home environmental sampling. Using contact plates as the control, cotton tip swabs, sterile gauze squares, toothbrushes and disposable dust cloths (Swiffers®, Proctor&Gamble) were compared. If surfaces were heavily contaminated, there was no difference between contact plates and any of these other sampling methods. When contamination was less, Swiffer sampling best correlated with contact plates for hard surfaces and textiles.[20] Only one side of the Swiffer sheet is used and an "X" is placed on the sample site. Target sites are dusted/swept until visibly soiled. Regardless of the fact the client has just cleaned, surfaces almost invariably have some debris present. The sample is placed in a self-closing plastic bag. At the laboratory, the entire surface of the Swiffer with the X is pressed against a fungal culture plate. Samples should be stored until results are final in the event the plate is readily swarmed with contaminant; plates can be recultured. Fungal culture plates must be examined daily because they are often swarmed with other contaminants. If the environment is heavily contaminated, plates may show growth of just *M. canis* often with highly suspect colonies within seven days. Gross colonies compatible with *M. canis* morphology typically are seen in the second week of contamination. With the two sample technique, the goal is to determine the efficacy of decontamination. Excluding carpeting (see below), repeated hard cleaning will readily decontaminate environments. If environmental contamination is found it is important to remind the client that this represents what was present on

the day of sampling. If cleaning has continued a common finding is that repeat cultures of the target site are negative.

NON-POROUS SURFACES

Hard Cleaning

The term "hard cleaning" refers to the mechanical removal of all gross debris via vacuuming, sweeping, or dusting of surfaces and mechanical washing of the surface with a detergent in water and thorough rinsing of the detergent from the surface. It is important to thoroughly rinse surfaces to remove detergent residue as some detergents inactivate disinfectants. Disinfectants are used to kill any spores not removed by hard cleaning.

Microsporum canis spores are protected in hairs and debris and readily bond to dust particles and removal of this material is critical to cleaning. Surfaces need to be hard cleaned until they are visibly clean. Hard cleaning alone can decontaminate *M. canis* infected contaminated surfaces or objects or rooms. At one shelter, dermatophytosis was introduced into a group housed room of cats. After the cats were removed, pre and post cleaning environmental cultures were obtained. Culture results revealed wide spread contamination and that hard cleaning alone decontaminated the room.[24]

Special Surfaces: Wood Floors

The hard cleaning of wood floors is always a concern for clients. It is important to remind clients that fungal spores do not grow in the environment and therefore will not grow in wood. To the author's knowledge, there are no safe disinfectants for use on wood floors especially since a contact time of 10 minutes is needed. The author has worked with many clients that have had environmental contamination of wood floors. The wood floors in homes were successfully decontaminated by daily removal of hair and dust using commercial dusting items (Swiffers and 'sticky Swiffers-see below). Floors were damp mopped using commercial wood oil soap for floors (Murphy's Wood Oil Soap, ColgatePalmolive).

Helpful Tools for Hard Cleaning

There are a number of cleaning implements that can make hard cleaning less onerous. General dusting is best done using electrostatically charged dust cloths to remove cat hair and spore laden dust from surfaces and items above the floor. Large amounts of gross debris are best removed with a vacuum cleaner. The ideal vacuum cleaner has a bag which will collect and trap debris and is easily discarded and does not vent excessive amounts of air. This is a common problem with canister wet/dry vacuums. If the vacuum cleaner has a bin, this could potentially contain a large amount of infective material so gloves should be worn and care taken to discard contents directly into a paper bag (or similar) that is immediately placed in their trash for pick up. Brooms are problematic because cat hair becomes trapped in the bristles, is difficult to remove, and they need to be decontaminated post use. Alternatively, floors can be cleaned with Swiffers®. Another excellent cleaning tool is the sticky Swiffer (3M Easy Trapper Duster, 3 M Minneapolis, MN.) The cleaning sheets are slightly 'sticky' and remove more floor debris than cloth or disposable floor cleaning sheets. The sheets are perforated so smaller sections can be quickly used to remove hair and debris from upholstery if vacuuming is not easily possible. Lint rollers are expensive to use on upholstery but duct tape is an excellent inexpensive alternative. Floors can be washed with disposable floor cleaning pads (e.g. Swiffer Wet Cleaning Cloths, Johnson). Another very helpful tool, especially in veterinary clinics, is a flat mop with reusable pads (3M Easy Scrub Flat Mop, 3M). These come with an easily changed cleaner-on-demand dispenser. One pad and one detergent cleaner can be used for the hard clean and a second pad can be used with the disinfectant. These are particularly helpful because they are

very effective cleaning tools, avoid mop and buckets and excessive wetting of surfaces, and decrease cleaning time. Over time, the cost of a re-useable flat mop system is less expensive than commercial disposable wet mops. All of these are readily available on major internet shopping sites or at cleaning supply stores.

Disinfectants

What to Look For On the Label

A common misconception among clients is that disinfectants are a first line step in decontamination. To the contrary, disinfectants are used after hard cleaning to kill any spores not removed by mechanical cleaning. There is a much wider range of effective disinfectants and enilconazole and various dilutions of house hold sodium hypochlorite (1:10, 1:32, 1:100) are no longer the only options.[1] *Trichophyton mentagrophytes* is the most common test pathogen for labelling of antifungal activity it was widely assumed that antifungal efficacy against the naturally infective form did not correlate. This was because early studies tested disinfectants in the presence of organic debris. Recently studies by the author found good correlation between disinfectant testing using the conidial form of *Trichophyton* and *Microsporum canis* and *Trichophyton* isolated infective spores sans organic debris.[20,25] *From a practical perspective, this means that disinfectants with a label claim against T. mentragrophytes are an option if coupled with hard cleaning.* It is important to read these labels because some products have multiple uses, e.g. cleaning vs disinfection and require different concentrations and/or contact times.

"One Step Cleaners"

The term 'one step' is often found on many disinfectants intended and is very confusing. Many clients will assume this literally means, "it' is all I have to do". One step cleaners are those that can clean a lightly soiled surface and sanitize it in one wipe. Test studies require documentation that shows 99% efficacy within 5 minutes against selective bacteria (e.g. *Staphylococcus*), not fungal spores.[26] Careful reading of products labelled as 'one step cleaners' will reveal a statement that if the surface is contaminated by organic material, this should be removed via hard cleaning prior to the use of the cleaner. There may also be a statement that the disinfectant does not need to be rinsed from the surface. One step cleaners can be used by clients for cleaning on days between "hard cleanings".

Effective Antifungal Disinfectants

There are many effective antifungal disinfectants, however several are worth special mention because of their wide spread use in homes or in veterinary clinics. These compounds were also found to be consistently antifungal (no growth or <10 colonies per plate) when used at 1:10, 1:5 or 1:1 spore to disinfectant dilutions.[20]

Sodium hypochlorite: The antifungal efficacy of household sodium hypochlorite has been well established and either 1:10 or 1:32 dilutions are commonly used as a treatment control in disinfectant studies. Sodium hypochlorite at 1:10 and 1:32 is consistently antifungal even after short contact times[20] The only time household sodium hypochlorite has failed in the author's laboratory was when the stock solution was opened and out of date or the dilution was not freshly prepared. If house hold sodium hypochlorite is the disinfectant of choice, the stock bottles should be used within the 'use by date' and dilutions prepared once a week. Reasons not to use sodium hypochlorite include, but are not limited to: lack of detergency, potential to react with other chemicals to create toxic gases, unpleasant odor, damage to hard surfaces, discoloration of fibers and colored surfaces, damage to floor finishes, rapid loss of efficacy once diluted.

Enilconazole: The antifungal efficacy of enilconazole is well established and it is also commonly used as a treatment control for disinfectant studies. It is available as concentrated spray or as a fogger. It is widely available in many countries and in the United States is available as Clinafarm® spray or Fogger, (Eli Lilly and Company). A major obstacle to more widespread use in the United States is that it is not available in reasonably priced small quantities. A 10 minute contact time is recommended even though enilconazole was antifungal at shorter contact times.

Accelerated Hydrogen Peroxide: This is one of the newer broad spectrum disinfectants to gain widespread use in hospital, veterinary clinics, and homes. Over the counter 3% stabilized hydrogen peroxide is antifungal but rapidly loses its stability.[25] Accelerated hydrogen peroxide (AHP) is a proprietary compound that is increasingly available worldwide. What makes this product different than over the counter hydrogen peroxide is that it contains surfactants (wetting agents) and chelating agents that help to reduce metal content and/or hardness of water. The latter of which may affect the efficacy of some disinfectants if high. This product has been tested using isolated infective spore suspensions of both *Trichophyton* and *M. canis* and is an effective disinfectant.[25,27] It is available as a concentrate or an over the counter ready to use form under several trade names. A 10 minute contact time is recommended even thought AHP was antifungal at shorter contact times.[20] Of important note is that the Materials Safety Data Sheet states that it should not be mixed with concentrated sodium hypochlorite product. If recommending this to clients it is important to make this clear. If a veterinary clinic is making the decision to use accelerated hydrogen peroxide as a disinfectant, it would be advisable to give serious consideration as to whether or not house hold sodium hypochlorite should be kept in the clinic.

Potassium peroxymonosulfate: This is the main component of Trifectant®(Vetoquinol,) and has broad spectrum antibacterial and antiviral properties. Early studies on the antifungal efficacy of potassium peroxymonosulfate did not reveal good antifungal efficacy, however in those studies the contact time was less than 5 minutes and the spore to disinfectant challenge was robust[21]. In recent studies this product was found to be antifungal against both *M. canis* and *Trichophtyon spp* when applied liberally and with a minimum contact time of 10 minutes.[27] More recent studies found a 2% solution to be more effective than 1%.[20]

Over the Counter Products: A recent study investigated the efficacy of ready to use over the counter products as alternatives to sodium hypochlorite. The criteria for selection were easy access by the consumer, preferably ready to use formulation, and label claim as antifungal against *T. mentragrophytes.* Active ingredients included sodium hypochlorite, quaternary ammonium, lactic acid, accelerated hydrogen peroxide, and an ethoxylated alcohol mixture. Products were tested with 1 and 5 sprays; all products were effective with a more liberal application and 10 minute contact time.

Frequency of Cleaning of "Easily Cleaned Rooms"

Again the major concern of contamination in the home is false positive fungal culture results. Even though infection in one or two cats can show large numbers of spores on environmental cultures[22], contamination in the environment can easily be managed.[23] With the exception of completely non-compliant owners the author has not encountered a home situation where decontamination was not possible.[28] In several instances contamination was never documented even though infected cats were present in the home. In one field study, environmental culturing (n=20) once weekly for eight weeks in a treatment ward housing 18 to 30 cats showed zero to one sites of contamination six of eight weeks and four sites two of eight weeks. The ward was thoroughly cleaned and disinfected only twice weekly with routine cleaning on other days.

For the pet owner with one or two infected cats receiving topical and systemic antifungal therapy that are reasonably confined, twice weekly hard cleaning followed by disinfectant is sufficient. Twice weekly decontamination is recommended early in the course of treatment with once weekly decontamination being adequate as the cat(s) are curing. Between hard cleanings it is important to mechanically remove hair and debris. One step cleaners, e.g. AHP ready to use sprays or AHP wipes are can be used on days between cleanings. More aggressive cleaning can be done if indicated, e.g. false positive fungal cultures.

Although not the focus of this chapter, it is appropriate to emphasize the importance of topical therapy. This will kill spores on the hair coat and greatly decrease spore shedding. Prior to the application of topical therapy, the hair coat should be combed to remove fragile hairs.

TEXTILES

Information in the veterinary literature on decontamination of textiles exposed to *M. canis* contamination is lacking. What is in the published literature describes findings associated with *Trichophyton spp* because this is the most common cause of tinea pedis in people. Care must be taken when extrapolating this information because this is a different pathogen and spore contact with socks worn all day and/or contaminated shores has no direct counterpart in cats.

Decontamination recommendations below are based upon experimental and field studies.[20] Almost all studies involving laundry items were conducted with a 15 years old domestic top loading washer and front loading dryer to best simulate what might be in an *average* home. One field study was conducted using contaminated laundry washed in a two year old front loading washer and dryer. Pilot studies were conducted using both hot and cold water, with and without added bleach, to determine the most economical way to clean laundry items. Experimental contamination was done using isolated infected hair suspensions containing no less than 500,000 spores per ml and using sterile towels contaminated with infected hairs collected from toothbrush. Laundry items simulating natural contamination used either actual soiled laundry from the cages of cats under treatment for dermatophytosis in a shelter or sterilized terry cloth wash clothes intentionally rubbed over untreated infected cats to simulate a 'high challenge'. As many 'mistake protocols' were tested as could be conceived and included both the following single and combination events: the detergent was not added, the cycle length was short, the laundry tub was over stuffed, the water level was low, and the laundry tub was not disinfected post cleaning. Suspensions of common laundry detergents were tested for antifungal efficacy as were samples of wash water containing ½ cup of household bleach in a 'regular' laundry load. Studies involving dry cleaning as a decontamination method were done using both experimentally contaminated items and naturally exposed items temporarily donated to the author; dry cleaning was done with informed verbal consent of the merchant. Hard surfaces, i.e. inside laundry tubs were cultured using the Swiffer technique. Textiles were cultured using enough 90 mm diameter fungal cultures so that the entire surface of the item could be cultured by direct inoculation.

Please note while reading the following that studies showed that contaminated laundry items can be decontaminated via washing. It is generally not necessary to exposed discard pet blankets and towels.

Mixing of Contaminated and Uncontaminated Laundry Prewashing

Experimental studies looking at risk situations pre washing used combinations of wet or dry contaminated laundry and wet or dry uncontaminated laundry. Testing revealed contamination in all possible combination scenarios when tumbled in a dryer for 30 seconds in a large biohazard bag. The highest risk scenarios involved wet laundry items, especially wet contaminated laundry mixed with wet uncontaminated laundry (100% contamination of all towels).

Recommendation: Known or potentially contaminated laundry should be kept separate from all other laundry items. At risk items should be stored in a plastic bag until washed and not contact other household laundry. From a practical perspective this means changing bedding or towels in contact with the pet at the end of the day and just before it is feasible to wash these items. Wet contaminated laundry represents the highest risk situation so handle it carefully.

Water Temperature

In the human literature, the recommended temperature for decontamination of *T. rubrum* from contaminated textiles is 60°C (140° F) vs 40°C (105°F) because this was consistently more effective for decontamination of *T. rubrum* exposed textiles.[29,30] Pilot studies conducted in a home setting revealed that in order to reach this temperature the hot water heater needed to be set at 'very hot'. Although the temperature of the water entering the wash tub was >60°C, this temperature was never maintained throughout the wash cycle no matter how low the water setting or short the wash cycle. In a home setting, this water temperature could result in accidental thermal injuries to family members if the hot water heater was not reset into a safe zone. Also in order to do several loads of laundry or repeat a washing of contaminated material, adequate time would need to be allowed for the hot water to heat. In any multiple animal facilities, it is impractical to use this temperature. Finally, this is not energy efficient.

Using experimentally contaminated textiles likely to come into contact with pets, i.e. linen, terry cloth, denim twenty 90 mm swatches of each were washed in hot water (≥60°C while the tub was filling) or cold water on a 15 minute cycle and cultured either immediately after washing. This was repeated three separate times. Out of 18 wash cycles, residual contamination was found four times but what is important to note is that the cfu/plate ranged from one to three.

Recommendation: *Microsporum canis* contaminated laundry can be washed in either hot or cold water.

Bleach and commercial laundry detergents

Commercial laundry detergent was not found to be sporocidal using an isolated fungal spore suspension test. Aliquots of tub water containing four or eight ounces of bleach at this dilution were also not sporocidal. When the above experiment was repeated with 4 or 8 ounces of household bleach added to the water there was no significant difference in the findings.

Recommendation: There is no preferred laundry detergent and the use of house hold bleach as a laundry additive is optional.

Transfer of Contaminated Spores to Unexposed Laundry During the Wash Cycle

Contaminated and uncontaminated textiles were washed together to look for transfer of infective material during the wash cycle. Samples were cultured immediately after washing. Transfer of infective spores from either direct contact during agitation or in the wash water was rare and the number of cfu/plate per swatch was at most two.

Recommendation: Transfer of infective material to non-exposed laundry is rare, but possible. This can be avoided by washing contaminated and unexposed laundry items separately.

Contamination of the Laundry Tub and Dryer Post Washing

Experimental studies using textiles contaminated with spore suspensions showed no contamination of either the laundry tub immediately post washing or the inside of the dryer or lint trap. Contamination of the inside of the laundry tub or lint trap was found in the top loading washer when heavily contaminated towels were washed. These towels had large amounts of visible hairs, many Wood's lamp positive, prewash caught in the fibers. When the surface of Swiffers used to sample the laundry tub was examined, intact hairs were commonly found. Contamination of the inside of the dryer was rare. Contamination of the lint trap (<10 cfu/sample) occurred when laundry items contained large amounts of infective material, however the air vented to the outside was more often heavily contaminated (e.g. >20 cfu/plate).

The laundry tub of the top loading washing machine was easily decontaminated after mechanical removal of hair via wiping with a towel and application of a disinfectant for 10 minutes. The lint traps was decontaminated by washing in an all-purpose house hold detergent.

In a shelter with a dedicated building for the treatment of infected cats that used front loading washers and dryers, contamination of the laundry tub, dryer, or lint trap was never found. This suggests that the newer high capacity laundry machines are more efficient at removal of spores and contaminated hairs.

In a small field study, the insides of top loading laundry tubs at three different public laundry sites were cultured. Pertinent to this study, small numbers of cfu/plate of *T. rubum* were isolated several times and was often culture positive for a wide range of yeast and gram positive and gram negative bacteria.

Recommendation: For all laundry situations, assume that there is possible contamination of the inside of the laundry tub post washing. Mechanically clean and remove all hairs from the inside of the tub, spray the surface with a disinfectant and keep wetted for 10 minutes. Post disinfection, the tub can be rinsed by running a water only wash cycle. Clean and wash dryer lint traps post cleaning of pet laundry. Be sure that dryer vents are not clogged and that there is adequate venting of air. The inside of the dryer is not likely contaminated but like all non-porous surfaces can be cleaned mechanically cleaned.

Efficacy of Routine Laundering to Decontaminate Laundry

Field studies washing towels either from the cages of cats being treated or towels rubbed over infected kittens consistently showed that the mechanical agitation of routine laundering was an effective method of decontamination of towels. In the most robust challenge, 50 face clothes were intentionally contaminated and washed in cold water on a long cycle followed by drying on the highest dryer temperature. Fourteen of 50 face clothes had one or two cfu/plate per side. When repeated, face clothes were completely decontaminated after two washings.

Even when the laundry tub did not reveal visible hairs when environmental cultures were obtained, the lint trap from the same load of laundry often had large numbers of hairs in the lint trap. Removal of hair is important in all decontamination procedures. In experimental studies and field studies, denim was the fabric most likely to be heavily contaminated with hairs and in one experiment, the textile with the most number of post wash positive cultures. Denim is also one fabric that is most likely to be line dried by a client. The number of washing to decontaminate exposed jeans was two.

In laundry error studies, the conditions that resulted in residual contamination were predictable, short laundry cycles and/overstuffed laundry tubs. Even so, the though the contamination was never large, i.e. >10 cfu/plate/item.

Summary Recommendations: Although laundry detergent is not sporocidal, detergents have wetting factors that aid in removal of dirt from surfaces, therefore there use is recommended. The use of bleach is optional. Laundry can be washed in hot or cold water. Agitation is the most important part of decontamination, therefore, wash laundry on the longest possible machine cycle taking extra care not to over stuff the machine. In most situations, one washing followed by drying is sufficient. Two washings immediately following each other are recommended if textiles are heavily contaminated or with hair or organic material (i.e. food, feces, urine, blood). Two washing for exposed denim items are recommended. Post washing the inside of the laundry tub and lint trap should be cleaned and disinfected. Follow this with a rinsing of the tub with a short cycle water wash. The inside of the dryer should be mechanically wiped clean with a detergent and soap. (Residual disinfectants may stain or discolor clothing if not thoroughly removed from inside the dryer).

Dry Cleaning

Silk ties intentionally contaminated by rubbing them with infected cat hair and temporarily donated client owned dry clean only items were successfully decontaminated by dry cleaning. All pet hair was visibly removed prior to having the item cleaned.

Recommendation: Exposed items that cannot be routinely laundered can be decontaminated via dry cleaning. It is important to mechanically remove hair from the fabric with a lint roller. Although the human health risk is low and dry cleaner personnel routinely handle clothing with gloves, place the items in a plastic bag and inform the merchant that the samples have been soiled by animals.

CARPETS

Decontamination recommendations for carpets are based upon laboratory studies and field studies.[20] For these studies, sterile carpet squares were contaminated by vigorously brushing the coat of Wood's positive *M. canis* infected cats. For the studies involving area carpets, Wood's positive *M. canis* infected hairs were deliberately placed on the surface and rubbed into the carpet fibers using a sterile toothbrush or carpets were contaminated by rubbing confirmed contaminated carpet squares or contaminated toothbrushes without hairs in the bristles on the surface to simulate areas where hairs had been removed but spores remained.

Pilot studies were conducted to determine both the best method of culturing contaminated carpets and whether or not repeat sampling had a significant effect on the culture results. Contact plates, toothbrush cultures and Swiffer sampling were compared and all were found to be equivalent in detecting heavy contamination. As few as 10 light Swiffer swipes detected heavy contamination; however 20 hard Swiffer swipes consistently detected any degree of contamination. Gauze squares were also tested but often spores were trapped in the fibers and not consistently inoculated onto the surface of a fungal culture plate. Two infected carpet squares were repeated cultured 25 times either by repeated direct impression onto fungal culture plates or repeatedly cultured with a new toothbrush. Neither repeated impression culturing nor toothbrush culturing decreased the number of cfu/plate; the first and last fungal culture plate had TMTC cfu/plate.

Carpets and Spore Viability

Research studies on carpet decontamination revealed some interesting finding. On carpets, spores may not be as viable as originally believed. As mentioned previously, 30% of samples previously having TMTC cfu/plate at the time of receipt were culture negative within less than five months and another 10% <10 cfu/plate. Another interesting finding was that thorough wetting of carpets appeared to have negative effect on the viability of spores. During review of the data it was noted that carpet samples that had low numbers of cfu/plate showed one of three patterns when cultured 24 hours after wetting. There was no growth, contaminant growth or a sudden increase in the number of *M. canis* colonies at 24 hours, i.e. a "bloom". The day 7 post treatment samples were

always culture negative for *M .canis*. One can hypothesize that wetting rehydrates dormant spores, triggers sporulation and the because of the lack of suitable nutrients (i.e. keratin) the spores die. The one thing worth noting is that these samples were free of visible cat hair. In addition, if naturally infected carpets (i.e. carpets post infected kitten romping) are cultured, different sites on the carpet will reveal vastly different culture results. At best, carpet sampling reveals what is found at that site of sampling; cultures can under or over estimate the amount of contamination depending upon sampling.

Vacuuming

Vacuuming carpets is commonly recommended as a means to decrease contamination.[2] The efficacy of vacuuming as a method to decrease contamination of carpets was tested on carpet samples (n=20) that had been rubbed over infected kittens. There was no difference in the number of cfu/plate cultured from any of the samples even after a cumulative vacuuming time of 60 seconds. Cat hairs, often Wood's lamp positive hairs, were present in the bin and it was culture positive.

Recommendation: In light the findings described above under "Carpets and Spore Viability", although vacuuming cannot decontaminate carpets, it is strongly recommended because it will remove hairs that may be protect spores from carpet cleaning procedures (see below).

Commercial Steam Cleaning and Carpet Shampooers

A very common question is whether or not steam cleaning or carpet shampooing will decontaminate carpets. Steam cleaning or hot water extraction uses a combination of pressure, agitation, and hot water to remove debris. Depending upon the equipment the water can be heated at the source (i.e. truck) to over 100°C > (212°F), however as it travels through the equipment much of the heat is lost. With carpet shampooers cleaning is achieved via mechanical brushing of carpets combined with vacuuming of soiled water. Both cleaning methods were tested using large area rugs each of which had been contaminated in 10 sites with infected cat hair. In one site on each carpet, a larger quantity of infected cat hair was used so that it was easily visible from a distance. Carpets were cleaned within 24 hours of contamination. In both situations, pre-cleaning contamination sites had TMTC cfu/plate, however post cleaning culture samples were different. The 20 contamination sites from the carpets cleaned with the carpet shampooer had TMTC cfu/plate per site. In contrast, only 2/20 contamination sites cleaned by steam cleaning had marked contamination (21 and 40 cfu/plate). The remaining sites were either culture negative or had <10 cfu/plate. When carpets were cultured one week all sites were not culture negative but there was a continued increase in the number of culture negative sites along with decreasing colony forming units. Two things were different with these test carpets vs the carpet squares. The first was that these area rugs were contaminated with cat hair and it was visible on the surface at the time of cleaning. Second, these carpets were not as thoroughly wetted as the carpet squares described above. The cat hair seemed to be a major factor because when the cleaned carpets were vacuumed and then cultured weeks later, there was a marked increase in the number of cfu/plate per site presumably due to vacuuming either mechanically damaging hairs protecting spores resulting in their release or by 'beating' spores up from deeper in the carpet. In a final experiment, all four carpets were thoroughly soaked with water until it seeped through the backing and were then cultured when dry and again at seven days post water treatment. Water treatment did decontaminate the carpets but it took nearly five days for the carpets to dry which is far from ideal in home.

Chemical Decontamination of Carpets

Area rugs were again contaminated as described above but in this study the carpet surface was thoroughly wetted with water and one of the following disinfectants chemicals was applied to the

surface: AHP (Accel®TB, Virox Technologies), enilconazole, Trifectant, a quaternary ammonium disinfectant, lactic acid 3.2% (Lysol, Reckitt Benckiser), ethoxylated alcohol mixture (Simple Green®, Sunshine Makers), a miconazole dog shampoo, a climbazole dog shampoo, and a ketoconazole dog shampoo. After the area was thoroughly wetting with the disinfectant the each carpet was scrubbed with a deck brush and was then allowed a contact time of 15 minutes. After this, a carpet shampooer filled with only water was used to remove the chemical disinfectant and any debris. This took a significant amount of time because many of the products were sudsy. After the carpets were thoroughly dry and carpets were repeatedly cultured. Pre-treatment samples revealed TMTC cfu/plate on all carpets. All of the commercial disinfectants decontaminated the carpets and all of the three antifungal shampoos were effective. It is important to note that the carpets were not vacuumed prior to cleaning.

General Recommendations: Given that carpets are more difficult to decontaminate than other household items, the best way to decontaminate carpets is to prevent it from happening in the first place, i.e. keep carpets and infected cats separated. Vacuuming will not decontaminate carpets but the mechanical removal of hair is important in minimizing contamination. It is very likely that over time spores will spontaneously die in carpets. If carpet decontamination is necessary, it is important to keep small children away from wet carpeting. Infection occurs via micro-trauma and inoculation of spores onto the skin. The post bloom seen after wetting may represent a risk to children playing on carpets. Although proprietary carpet cleaners are not sporocidal, repeated carpet cleaning with water and detergent is one option. Another option is to vacuum, apply a chemical disinfectant, and then clean the carpets. Clients with concerns about using chemicals on carpets may want to consider using a commercial antifungal dog shampoo instead of a disinfectant. If a client is concerned about the safety of a disinfectant, refer them to the product label and the on-line MSDS.

BOWLS

Water, food dishes, and litter boxes can be easily decontaminated by aggressive cleaning and washing with detergent and hot water followed by a thorough rinsing. This protocol consistently completely decontaminates glassware used to prepare fungal spore suspensions.[19]

CLIPPERS

Clippers are best decontaminated by hard cleaning followed by autoclaving. If this is not possible, contaminated clippers can be decontaminated if gross debris is meticulously removed from all of the surfaces and then sprayed with Clipperside (King Research). The surfaces should be wetted for 10 minutes and then the procedure repeated. It is important to remember to clean the plastic base and electric cord.

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