

General Information

- **Dermatophytes** are fungi that are most commonly found on the skin and hair of animals and people. Cutaneous infection caused by dermatophytes is referred to as **ringworm, tinea, dermatophytosis** or **dermatomycosis**.
- Some of the more common zoonotic species of dermatophytes found in animals include *Microsporum canis* (primarily dogs and cats), *Trichophyton verrucosum* (primarily cattle), *T. equinum*, and *T. mentagrophytes*.
- Dermatophytes primarily associated with humans (e.g. *T. rubrum*, the cause of athlete's foot) do not normally infect animals, but rare cases have been reported, and an animal's fur can become contaminated with the fungi.
- Dermatophytes, specifically *M. canis*, are very **commonly found on cats**, but almost any animal species can transmit dermatophytes of one species or another. Signs of infection in animals are not always apparent.
 - **Cats** are considered the **primary zoonotic source of dermatomycosis** in humans.
 - Dermatomycosis is the most commonly reported zoonotic disease in people who work with cattle.
- Dermatomycosis is normally limited to cutaneous infection, but in high-risk individuals (e.g. very young, elderly or immunocompromised) the infection can spread, resulting in much more severe systemic illness.



Prevalence & Risk Factors

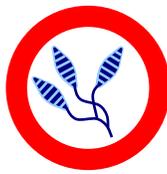
Humans

- Dermatomycosis occurs all over the world, but in general it is not reportable so the overall incidence is unknown. Many mild cases likely go undiagnosed.
- Various studies have reported that zoonotic dermatophytes are responsible 20-50% of human cases of dermatomycosis. There is often an impression that transmission of ringworm does not occur frequently between animals and people. A study in England in the mid 1980s looked at 23 families that had contact with clinically or subclinically infected cats, and found 50% of people in the study became infected with *M. canis* (44.2% of adults, 80% of individuals less than 16 years old).
- Dermatomycosis is more common in children, likely in part because infection induces some immunity to reinfection. In general, the very **young**, very **old**, or **immunocompromised** are more likely to be infected.
- Transmission of dermatomycosis from pets is of particular concern due to the **close contact** pets typically have with their owners, and because animals can carry zoonotic dermatophytes subclinically.
- Transmission from **rodents** can occur through contact with shed epithelial debris in the environment, or indirectly via dogs and cats that hunt infected rodents and become infected or contaminated themselves.
- There appears to be some **genetic predisposition** to chronic dermatomycosis in humans, and possibly cats, likely because cell-mediated immunity is essential to clearing infection. Infection may persist in individuals that only develop a primarily antibody-mediated immune response.

Animals

- Among animals suspected of having dermatomycosis, studies report positive culture rates of 14.3-65% in dogs, and 33.9-92% in cats. In clinically normal animals, culture-positive rates range from 3.5-20.5% in dogs, and 2.6-28.2% in cats. The majority of isolates from both dogs and cats are *M. canis*.
- Studies have reported infection rates of *M. canis* in cats between 6.5% and 88% in situations where **cat-to-cat contact** was common. It is more commonly found in **stray cats** and those from **multi-cat facilities**. A study performed on cats from single-cat households found no *M. canis* in cultures from 172 cats.
- Dermatomycosis is more common in **warm, humid** environments. **Crowding** and **close contact** increases the likelihood of disease transmission (e.g. cattle housed indoors during the winter). Any type of **minor skin trauma** or **chronic moisture** also increases the likelihood of infection.
- **Long-haired animals** may be predisposed to dermatomycosis, as hair mats can interfere with normal grooming and provide an ideal environment for fungal growth on the underlying skin. However, at least one study found that long-haired cats were not at increased or decreased risk of carrying *M. canis*.
- **Excessive bathing a grooming** may also predispose animals to infection by increasing the hydration of the skin and removing sebum and serum (both of which are fungistatic) and superficial epidermal cells, which are part of the host's normal defensive barriers.





Habitat & Environmental Survival

The natural habitat of dermatophytes is the skin of humans and animals. The fungi grow around hair shafts and in the superficial layers of skin. *In vivo*, dermatophytes form **infective arthrospores** at the ends of their long filamentous hyphae. Arthrospores may remain viable for months or even years in desquamated epithelial cells and hairs in the environment. Hair and cellular debris may actually protect the fungi to some extent from the action of certain disinfectants (see Infection Control below). The arthrospores germinate when exposed to appropriate conditions (e.g. warm, humid) which are typically encountered when they come in contact with broken or macerated skin. In culture media, the fungi form more complex microscopic structures called microconidia and macroconidia, which can be used to identify the fungal species. The conidia released from these structures may also be infective.



Transmission of Dermatophytes

- **Infective arthrospores** of dermatophytes are present in the large numbers on hair and skin cells shed by infected individuals. *The infection is quite contagious.*
- People and animals can be infected by **direct** skin-to-skin contact with another infected person or animal, or by **indirect** contact through things like clothing, blankets or hairbrushes that are contaminated with infected hair and skin cells.
- Arthrospores can also be spread like dust in **air currents**, or by **vectors** like fleas.
- **Arthrospores cannot penetrate normal intact skin**, but any kind of minor trauma or maceration due to moisture can allow the fungus to penetrate the keratinized layers.
- Zoonotic dermatophytes spread more easily between animals and people than between people alone.
- Animals are occasionally infected with geophilic fungi such as *M. gypseum* from digging and rooting in **rich soil**.
- Infection with *Trichophyton* spp. is commonly associated with direct or indirect contact with **rodents**.

Symptoms and Signs

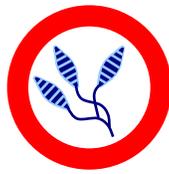


Humans: Like many fungi, dermatophytes grow best in warm, moist environments, but they can grow almost anywhere on the body. The incubation period for infection is 1-2 weeks. In children 4-11 years old, the disease most commonly occurs on the scalp (tinea capitis). The infection can be, but is not necessarily, quite itchy. A classic “ringworm” skin lesion tends to spread out from one point on the skin, causing hair loss as it progresses, resulting in a patch of alopecia. The outside (most active) edge of the infection often appears as a red ring, from which the condition gets its name (tinea circinata)(photo left: ringworm lesions on a person’s arm (credit A. Yu)). The centre of the lesion may begin to heal, and the hair may start to grow back, even as the alopecia progresses peripherally. Fungal species that are adapted to humans tend to cause less pronounced clinical signs of infection. In HIV/AIDS patients, lesions from *T. mentagrophytes* and *M. canis* infection may disseminate widely over the skin all over the body.

Animals: Not every animal that is infected with ringworm develops signs of infection. It has been estimated that ~90% of cats carrying dermatophytes **do not show any clinical signs**. The incubation period is generally 1-3 weeks. Dermatophytosis can cause a broad range of skin lesions in dogs and cats, including alopecia, scaling, and crusting (most commonly), and/or papules, pustules, nodules, ulcers, comedones (feline acne), classic “ringworm” lesions (more common in dogs than cats), and nail bed infections (onychomycosis). The condition cannot be diagnosed on clinical signs alone, because it can **mimic almost any skin disease**, particularly in cats. For this reason, dermatophytosis is likely overdiagnosed in clinical practice. Cats most commonly develop lesions on their **face and paws** (see picture right (credit A. Yu)). Lesions are variably pruritic. If an animal presents with generalized dermatophytosis, an underlying systemic illness should be ruled out.



Laboratory **mice** and **guinea pigs** are typically affected by *T. mentagrophytes* but may not have any apparent lesions. Lesions in **horses** can range from dry, bald, thickened, scaly skin and brittle hair, to more exudative lesions that cause hair to stick together and are extremely itchy. **Calves** are affected more frequently than mature cattle, and typically develop grey-white, dry lesions on the face and neck that then scab and leave an alopecic area. **Sheep** are not commonly affected by dermatophytosis, but infection can occur, particularly on the head and face, and is easily spread between sheep by sheering implements and close contact after sheering. The agents of dermatophytosis in **swine** and **chickens** are rarely transmitted to humans, but a few cases have been reported.



Diagnosis of Dermatomycosis

Wood's Lamp (filtered UV light, 320-400 nm wavelength): Approximately half of *M. canis* isolates will fluoresce blue-green under a Wood's lamp, but only when growing **on the hair shafts**, not on the nails or in scale. Various other debris in an animal's haircoat may fluoresce as well, therefore suspicious hairs should also be examined microscopically. **Other species of dermatophytes do not fluoresce**, therefore this is a very insensitive test, but it is very quick and easy to perform as a screening test. Always allow the lamp to warm up for a few minutes examining an animal. Examine the entire coat slowly and carefully with the room lights out.

Microscopy: This technique is used to detect fungal hyphae and spores on scales and hair shafts from the active edge of a lesion. It is a relatively **insensitive** test, but is most effective when hairs are selected based on fluorescence under a Wood's lamp. Visualization of fungal elements can be improved by **clearing the keratin** from opaque hair shafts using 10-20% potassium hydroxide (KOH), either overnight or gently heated for ten minutes. It can be **easy to misinterpret** debris, normal hair shaft structure or incidental saprophytic fungi as dermatophyte structures. Infected hairs tend to be thicker, frayed, filamentous and indistinct compared to normal hairs.



Culture: Definitive diagnosis of dermatomycosis is based on fungal culture, but both false positive and false negative results can occur. Colonies may begin to grow in as little as 5-7 days, but **at least three weeks** should elapse before a culture is called negative. Microscopic examination of the cultured specimen after 7-10 days of growth permits identification of the fungus to the species level. Cultures should be protected from ultraviolet light and from drying out (e.g. in a covered container with a damp towel). Incubating culture plates at 24-27°C instead of room temperature may also improve growth. Dermatophyte colonies are white to buff colour, but never green, grey, brown or black. The culture medium should **turn red at the same time** the colony first appears, not later.



- **Toothbrush technique:** This is the recommended method for collecting culture samples from pets, particularly for mild or subclinical infections. A new (straight out of the package) human toothbrush is brushed vigorously through the hair around any suspect lesions or the animal's entire coat (particularly face and ears in cats) for a few minutes, and then gently pressed onto a plate of culture medium (dermatophyte test medium (DTM)). **Owners can be taught** how to take the samples for follow-up cultures, which avoids additional contact/transport/handling of potentially infected animals.

Because cats so often carry dermatophytes subclinically, a positive culture in a cat with skin disease does not rule out other causes. **Histological** identification of dermatophytes in biopsy specimens is useful for confirming the significance of culture results, but is not as sensitive as culture for initial diagnosis. **Serological** tests for detecting exposed and infected animals, and **molecular-based tests** are under active investigation, but currently are not commercially available.

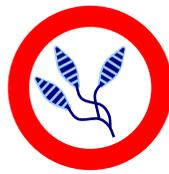
Dermatophytes are **not part of the normal fungal flora** of dogs and cats, but they can be isolated from clinically normal pets. It is not usually possible to differentiate between an animal with subclinical dermatomycosis and an animal with incidental contamination of its hair coat. Pets may also carry many different kinds of fungi on their skin and hair coats that do not cause infection in animals or people.

Treatment of Dermatomycosis

Most immunocompetent individuals eventually develop immunity to invading dermatophytes and clear the infection, even if no specific treatment is given, but this may take several months (e.g. 60-100 days in cats). Nonetheless, any animal (or person) found to be carrying a zoonotic dermatophyte should be treated in order to decrease the risk of spread to other animals and people.

Humans: Most cases of ringworm can be treated with either topical or oral antimycotic medication. Topical treatment with an azole medication is typically recommended. In general, the key is that treatment must be continued for a long period of time (2-3 weeks) and reinfection must be avoided.

Animals: Systemic therapy is the most effective at shortening the course of disease in animals, whereas **topical therapy** primarily reduces ongoing environmental contamination; the **combination** results in a more rapid resolution of infection than either therapy alone. **Body clipping**, particularly long-haired animals, is recommended, but may not be necessary for shorthaired animals with only a few focal lesions. **Concurrent environmental decontamination is essential** to effective treatment. Recheck cultures should be started 4 weeks after treatment is initiated. Treatment should be continued until 2-3 weekly or biweekly cultures are negative.



- ▶ **Itraconazole** is the drug of choice for systemic therapy in small dogs and cats, but it is quite expensive. Give PO q24h in dogs 5-10 mg/kg, or cats 10 mg/kg. Other regimens (e.g. pulse therapy) in cats may also be used.
- ▶ **Griseofulvin** has been used widely for treating dermatomycosis in dogs and cats, but it is becoming hard to find. Effective doses may be toxic, and depend on the formulation used (microsize or ultramicrosize).
- ▶ **Ketoconazole** should be reserved for animals intolerant of griseofulvin and for which itraconazole is cost-prohibitive. It may cause vomiting, hepatotoxicity and adrenal suppression. In dogs, give 10 mg/kg PO q24h.
- ▶ **Fluconazole** is effective against *T. mentagrophytes* infection in guinea pigs, but based on clinical experience and *in vitro* studies, it has no advantage over other drugs for treatment of dermatomycosis in dogs or cats.
- ▶ **Terbinafine** has been used to treat dermatomycosis in cats, but it is not licensed for veterinary use. It is very expensive, and has not yet been evaluated in dogs.

The effectiveness of lufenuron as an antimycotic is questionable, therefore its use is not recommended in lieu of drugs with proven efficacy such as itraconazole.



Topical treatments include **enilconazole** solution, **lime sulfur** solution and **miconazole** shampoo. There is no evidence that spot treatment is effective. Instead the **whole body** should be treated twice weekly. When applied correctly, lime sulfur is virtually non-toxic and can even be used on neonatal pups and kittens. Enilconazole appears safe to use in cats, but they must be prevented from licking the compound off their fur. Captan, chlorhexidine, clotrimazole, povidone-iodine, ketoconazole and bleach are significantly inferior topical antifungal agents for dermatomycosis.

Treatment **failures or relapses** are often due to poor **compliance**, inadequate **duration** or **type** of therapy, inadequate **environmental decontamination**, **underlying illness** or **incorrect diagnosis**.

Vaccination

Modified live vaccines for *T. verrucosum* in cattle and *T. equinum* in horses are available in Europe. Vaccination has been used to successfully eradicate *T. verrucosum* in cattle in some countries. Dermatophyte vaccine development for cats in particular is ongoing, but currently no vaccine is available for companion animals.

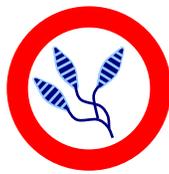


Infection Control For Dermatomycosis in Pets

Infected Animals: Animals with known or suspected dermatomycosis should be isolated to prevent spread of the infection, ideally by keeping them confined to an easily-cleaned, separate room. Whether lesions are present or not, treatment with topical and oral antimycotics is recommended. Even though lesions may appear focal, an infected animal may have infective fungus on any or all areas of its fur/skin.

Environment: Eliminating dermatophytes from the household or clinic environment can be difficult, because the fungus can be found anywhere that an infected animal (or person) sheds hair or skin cells. A study in Italy found dermatophytes on the floor of different rooms in 15 of 50 veterinary clinics sampled. Here are some guidelines for environmental disinfection of dermatophytes:

- Dust all surfaces and ledges with a **disposable dusting cloth** (e.g. Swiffer).
- All bedding, brushes, combs, rugs, cages, etc. should be **vacuumed** and **scrubbed** with hot water and detergent. This should be followed by application of an **effective disinfectant** (see below). It is best to discard any items that cannot be thoroughly disinfected.
 - Walls, floors, lamps, etc. should be scrubbed and cleaned in a similar manner.
 - Ideally use a **wet-dry vacuum** to remove any dirty water after cleaning.
 - Ensure sufficient **contact time** with disinfectant for all surfaces (e.g. at least 10 minutes for bleach).
 - Wear appropriate **protective clothing** (e.g. gloves, goggles) and ensure the room is well **ventilated** during disinfection. Ideally place a fan by a window to blow air out of the room to the outdoors.
- Use a **disposable mop pad** to clean non-porous surfaces in high-traffic rooms.
- **Carpeted areas** may be impossible to effectively decontaminate. If possible, remove the carpet and either wash it in hot water and bleach, or discard it. Otherwise, frequent vacuuming with immediate disposal of the collection bag is necessary. However, **regular vacuuming may actually spread fungus** further around a room. To avoid this, use only vacuums equipped with a **HEPA filter**, **steam cleaning** or a **central vacuum unit**.
- **Vehicle interiors** should be decontaminated as much as possible in a similar manner.



- **Curtains** can be dry-cleaned at a professional cleaner.
- Clean all **heating vents**, and install a good-quality furnace filter. The filter should be changed according to the manufacturer's recommendations, and at the very end of the decontamination process. Ideally, do not keep infected animals in a room with a cold air return.
- Avoid blowing air from heavily contaminated rooms to other parts of the building. If fans are used to improve air circulation, they should be pointed to blow air outside.
- Use a **dehumidifier** to reduce the humidity in heavily contaminated/isolation rooms.

Mopping/vacuuming and dusting in heavily contaminated rooms should be done daily, and disinfection should be done at least weekly. In other rooms, cleaning and disinfection should be repeated at least once every 4-6 weeks (the more often, the better) until all affected animals and people have eliminated the fungal infection.



In catteries, additional recommendations for control of dermatomycosis include:

- Cats should be separated into clean and contaminated rooms/areas according to individual status.
- Use disposable garbage bags to cover clothes while treating infected cats or working in contaminated rooms.
- Wear designated footwear in areas housing infected cats.

Studies have shown that many environmental disinfectants labeled for use against dermatophytes are, in fact, not effective. The chemicals are typically tested against a suspension of fungal organisms in a test tube, but the fungi are usually found on small fragments of infected hairs, which may protect them from the actions of some disinfectants. Disinfectants that are effective against dermatophytes in the environment include:



- **Household bleach** (1:10 to 1:100 solution in water): Cheap and readily available.
- **Lime sulfur** (1:33 solution): Effective, but many people find the smell objectionable.
- **Enilconazole** (0.2% solution): A licensed topical antimycotic for dogs and horses which is also approved for use in catteries but not for household use.

Use of other products, including Virkon-S® (a detergent-peroxide based product) and Peroxigard® (an accelerated hydrogen peroxide product) have been recommended in some cases, but at least one study has shown Virkon-S to be ineffective at the manufacturer's recommended dilution, or inferior to other products.

Prevention of Dermatomycosis

Control and clean-up of a ringworm outbreak can be quite an undertaking. Eradication of ringworm from an animal shelter or cattery (50-100 cats) would be expected to take 5-6 months. If infection can be identified early, lesions can potentially be kept covered and movement of affected animals can be restricted to reduce the extent and amount of environmental contamination. The following recommendations apply to all pet owners:

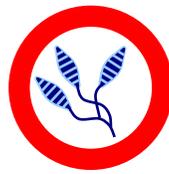


- **Early identification of ringworm is key.** If a pet develops bald patches, particularly if they're itchy, it should be examined by a veterinarian as soon as possible.
- If anyone in the household develops an area of infected skin (especially if it appears as a red "ring"), keep it covered with a piece of clothing or a bandage and see a physician.
- Clean all pet grooming supplies (e.g. brushes, combs) regularly.
- Promote proper **hand washing** after handling any pet, or potentially contaminated items.
- Any new pet (especially a cat) acquired from an animal shelter, rescue group or pet store should have a toothbrush culture of the hair coat performed as part of the animal's routine examination, particularly if there are any high-risk individuals in the household.

The coat of a cat (or dog) may become contaminated with dermatophyte spores while it is at a show, veterinary clinic or any other multi-cat environment. If contamination is very minor, many cats likely eliminate the infectious organisms through grooming. Long-haired cats may be more of a risk for casual persistent carriage of ringworm if they are exposed for multiple days. A preventative dip in lime sulfur is a good precaution for such cats entering or returning to a multi-animal household from an outside multi-cat environment, if ringworm is a concern.

Considerations For Therapy Animals

Control of zoonotic dermatophytes is not specifically considered in the guidelines that have been developed to reduce the risk of pets involved in animal visitation programs acquiring or transmitting infectious diseases. It is prudent to include a toothbrush culture with any regular examination (i.e. twice yearly) of cats involved in such a program, particularly if the animals are from a multi-cat household. The prevalence of dermatomycosis in clinically normal dogs is likely low enough that this is unnecessary for these animals.



Pet Owners

Diagnosed With Dermatophycosis

If a pet owner is diagnosed with a zoonotic dermatophyte infection (particularly *M. canis*), any pets should be examined by a veterinarian and a toothbrush culture performed. Because these fungi can be transmitted from animals to people and vice versa, a positive culture from a pet does not necessarily implicate the animal as the source of infection, but all culture-positive animals should be treated to prevent ongoing contamination of the environment and reinfection of other household members and pets.

Zoonotic Disease Risk

The zoonotic risk to the general population posed by dermatophytes in house pets such as dogs and cats is:



Individuals with compromised immune systems (e.g. HIV/AIDS, transplant and cancer patients) are more susceptible to many kinds of infections, including those which may be transmitted by pets. While these individuals are not advised to get rid of their pets, precautions should be taken to reduce the frequency of contacts that could result in pathogen transmission.

- Pets that develop any kind of skin lesions should be promptly examined by a veterinarian and appropriate testing performed to determine the cause as soon as possible. Immunocompromised individuals should avoid handling such animals at least until the diagnosis is known.
- Keep cuts and damaged skin covered to prevent contamination with pet hair and dander.
- Do not allow pets to sleep in the same bed as an immunocompromised individual.
- Thorough **hand hygiene** after touching any animal, as always, is very important.



Infants and young children (less than 5 years old) are more likely than adults to extensively handle animals if given the opportunity, more likely to touch their faces or mouths, and less likely to wash their hands after handling an animal. Children may “snuggle” with pets; this very close contact can increase the risk of disease transmission.

- Young children should be supervised when playing with animals, and an adult should ensure that they wash their hands afterwards. Older children should be taught to do the same.
- Avoid handling animals with skin lesions of unknown origin.
- Keep cuts and damaged skin covered to prevent contamination with pet hair and dander.

For these groups, the zoonotic risk posed by dermatophytes in house pets such as dogs and cats is likely:



Additional Information

- DeBoer DJ, Moriello KA. Dermatophytosis. In: Greene CE, ed. Infectious Diseases of the Dog and Cat. 3rd ed. Edinburgh: Elsevier Saunders, 2006:550-565.
- Guillot J, Latie L, Deville M, Halos L, Chermette R. Evaluation of the dermatophyte test medium RapidVet-D. Vet Dermatol. 2001;12:123-127.
- Mancianti F, Papini R. Isolation of keratinophilic fungi from the floors of private veterinary clinics in Italy. Vet Res Commun. 1996;20:161-166.
- Moriello KA. Diagnostic techniques for dermatophytosis. Clin Tech Small Anim Pract. 2001;16:219-224.
- Sparkes AH, Robinson A, MacKay AD, Shaw SE. A study of the efficacy of topical and systemic therapy for the treatment of feline *Microsporum canis* infection. J Feline Med Surg. 2000;2:135-142.
- White-Weithers N, Medleau L. Evaluation of topical therapies for the treatment of dermatophyte-infected hairs from dogs and cats. J Am Anim Hosp Assoc. 1995;31:250-253.