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Environmental detection of *Microsporum canis* arthrospores in the households of infected cats and dogs

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Microsporum canis is the dermatophyte most frequently recovered from canine and feline ringworm cases. The household environment can be contaminated both by symptomatic animals and through asymptomatic *M canis* carriage, resulting in a potential human health risk. The load of *M canis* arthrospores was determined in households harbouring infected pets, in order to evaluate the infectivity of the animals versus the environment. The environments inhabited by 30 symptomatic animals (21 cats and 9 dogs) infected by *M canis* were examined by sampling both surfaces and indoor air. The surfaces were examined by means of contact plates; the air sampling was performed with a Sas super-100 AIR SAMPLER (PBI, Italy). Environmental contamination was detected in all households with cats, while only four out of nine houses harbouring dogs were found positive. The frequence of isolation in each sampling, and the results in terms of colony forming units per plate in the different houses appeared to be quite homogeneous. Heavily infected environments harboured kittens only. Infected owners were observed in eight households, in all of which at least one infected cat was present. No history of human dermatophytosis in households harbouring dogs was found. On the basis of our results, infected cats appear to cause substantial environmental contamination, and provoke a substantial presence of viable airborne fungal elements. Dogs seem to be of lower importance in the spread of *M canis*: they contaminated surfaces, but they never contaminated the air. The results of this study confirm the potential leading role of the feline species in the environmental spread of *M canis*.

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Introduction

Microsporum canis is the dermatophyte most frequently recovered from canine and feline ringworm cases—it is responsible for 97–100% of canine and feline cutaneous mycoses in Italy (Filipello Marchisio et al 1995). In a recent study evaluating pets presenting with clinical signs of ringworm in central Italy, dermatophytes were isolated from 23% of the animals and *M canis* was cultured from 83 and 97% of positive canine and feline specimens, respectively (Mancianti et al 2002). This species also has a relevance in public health as the leading agent of both tinea corporis (Mercantini et al 1995, Filipello Marchisio et al 1996) and tinea capitis (Romano 1999), although in general within Europe there has been an overall increase in the number of these cases caused by anthropophilic fungi such as *Trichophyton tonsurans* (Hay et al 2001). Untreated animals infected with *M canis* usually recover, but the infection may last for months to years in some cases.

Both effective therapy of the infected individual and environmental control are required to eradicate the infection. A contaminated environment acts as a source of infection and reinfection for both animals and humans (Gonzalez Cabo et al 1995, Moriello and DeBoer 1995) and up to 1000 arthrospores per cubic meter of air space were recovered in a house with an *M canis*-infected cat (Symoens et al 1989). Previous studies

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have demonstrated that the household environment can be contaminated either by symptomatic cats or by cats with asymptomatic *M canis* carriage (Scott et al 2000). For this reason, and the fact that arthrospores are very resistant and can remain infectious in the environment for 12–24 months (Sparkes et al 1994), the potential for human exposure from the environment is high. It is estimated that approximately 50% of humans exposed to infected cats acquire the infection, and in about 30–70% of all households with infected cats at least one person becomes infected (Pepin and Oxenham 1987). Dogs are generally believed to be less infectious for people, but specific data on this are lacking in the literature.

Direct contact with infected hairs and scales or fungal arthrospores and hyphae on fomites and contact with a contaminated environment are the modes of transmission of the disease. The minimal infective dose is unknown, and the natural defences of the host and the invasiveness of the dermatophyte are likely to play a role. Furthermore combing, ectoparasites, pruritus and disorders of keratinization may disrupt the integrity of skin barrier predisposing the host to the infection. Dermatophytosis is thus both a contagious disease among animals and an important zoonosis, especially with the increased number of dogs and cats being kept as pets.

The aims of the present paper were to determine the burden of *M canis* arthrospores in domestic environments harbouring infected pets, to compare the results obtained from air and surface samples, and to evaluate the infectivity of the animals versus the environment.

Materials and methods

Animals

Thirty symptomatic animals (21 cats and 9 dogs) of both genders, with ages ranging from 2 months to 9 years, naturally infected with *M canis* were identified for this study, each from a different household. Animals were classified as puppies/kittens if less than 1 year of age, as adults if they were greater than 1 year of age. All the animals belonged to owners, and they could roam free in the indoor environment. The diagnosis of *M canis* was based on clinical, microscopic and cultural methods. During physical examination the animals were examined under Woods lamp illumination. Fungal culture was chosen as the definitive diagnostic technique, and was used in all cases of suspected ringworm in both cats and dogs. Cultures were also performed to assess the survival of *M canis* arthrospores. Breed, age and clinical signs of the animals were recorded. Details of in-contact human infection were sought, and in 7 out of the 21 cats with *M canis*, owner co-infection was reported. On the basis of physical and clinical examination, they were considered free of other disease: no fleas, lice or mite infestations were present. All the cats included in the study were FIV- and FeLV-negative on routine screening.

Environmental sampling

The home environment of the 30 animals was sampled for the presence of viable *M canis* particles by surface testing and collection of indoor air samples. These investigations were carried out after the animals were found to be culture-positive, and immediately before the beginning of specific treatment. At the time of sampling, all the households had been swept daily to keep them clean (and mechanically remove hairs and litter) but no disinfectants had been used.

Household surfaces were evaluated by means of contact plates (RODAC, PBI International S.p.A., Milan, Italy). The sampling was carried out as previously described (Mancianti and Papini 1996) on soft (draperies, carpets, quilts) and hard (furniture and floors) surfaces. In each of the households included in the study, 10 plates were employed for the surface sampling, five from hard surfaces and five from soft ones. The sampling was randomly conducted in areas frequented by the infected animals. It was thus impossible to standardize the results obtained in relation to a particular surface unit.

Five other plates were used for air sampling which was of particular interest in this study. Air sampling was performed with a bioaerosol sampler, SAS (Surface Air System) super-100 (PBI International, Milan). This is a commercial air sampler used for monitoring airborne fungi (Jensen 1995). The sampling procedure was undertaken following the manufacturers' instructions. At each sampling 1000 l of air was examined. Air was sampled approximately 1 m above the floor and one sample per room was collected. Following culture, the colony forming units (CFUs) were determined to evaluate airborne fungal load and the counts obtained were expressed as CFU per cubic meter of air (CFU/m^3), so providing a quantitative evaluation.

All samplings were carried out in absence of the infected pets, and a score was ascribed to each sample, as follows:

- Heavy contamination (HC), >50 CFUs/plate;
- Intermediate contamination (IC), 5–50 CFUs/plate;
- Low contamination (LC), <5 CFUs/plate;
- Absence of contamination (NC), no fungal growth.

The scores of the individual plates were then used as a basis to ascribe a score for both surface and airborne contamination of the whole household, the highest plate score being used as the score for the whole house.

All the samples were cultured on Mycobiotic agar (Difco, USA) at 25°C for 30 days as previously described by Mancianti and Papini (1996). After 30 days, the plates where *M canis* failed to grow were discarded as negative.

Relationships between data were analyzed by the chi-square test.

Results

Details of the infected animals, clinical signs, Woods lamp evaluation, co-habiting pets, owners and results of environmental assessment are shown in Tables 1 and 2 (for cats and dogs, respectively). Overall, environmental contamination (surface and/or airborne) was present in all houses with infected cats, and in four of nine houses harbouring infected dogs.

The results relating to different plates in the same house appeared quite consistent: Households classified as HC always consisted of positive plates with more than 100 CFUs/plate; counts in households classified as IC ranged from 3 to 21 CFUs/plate (mean=6.8, σ=6.74) with a variable number of positive samples per house (20–100%). Households classified as LC always had only 1 CFU/plate and only 10–20% of plates were positive.

For the surface sampling, heavy contamination was found in eight households, intermediate contamination in seven, low contamination in eight, and no contamination in six. All the HC and IC environments harboured cats; the lower scores (LC and NC) were found in environments inhabited by six cats and nine dogs. The higher level of contamination observed in cat households was significant compared to that in dog households (P=0.05).

There was good agreement between surface and airborne contamination in this study. In highly contaminated environments (n=8) all the surface specimens were HC and contamination of the air was always observed at the same level (HC). Households with intermediate contamination of surfaces (n=7) yielded intermediate (n=4) or low (n=3) contamination of air specimens, and those with a low surface contamination (n=8) yielded an absence of positive results in air in three cat households and in all the four dog households. However, a low level of airborne contamination without any evidence of surface contamination was found in two feline households.

The households heavily contaminated harboured cats aged from 2 to 12 months, mostly with extensive lesions, while a low level of contamination was found in households with adult cats or dogs.

The lowest presence of fungal elements in air specimens was found in five cases, and the correspondent contamination degree for surfaces was present in only one household: in three cases a highest IC score was demonstrated, while in another one the dermatophyte was not isolated from surfaces. In three houses *M canis* was never isolated from the air, but it was present at a low level on surfaces.

Infected owners were observed in five HC and three IC environments, all harbouring cats. In most cases where human co-infection was present, there was a kitten in the house. Symptomatic co-inhabiting pets were also found in four of the 30 households. Recovery of the dermatophytes from asymptomatic pets' hairs was obtained in an additional four households, inhabited by seven cats (one household), three cats (one household) and two cats (two households): this situation was considered a state of passive *M canis* carriage.

Discussion

In this study, infected cats appeared to be a striking source of contamination in their environment, and also provoke a massive airborne presence of viable fungal elements. Dogs seemed to be of lower importance in the environmental contamination of *M canis*, with five of nine canine households failing to have detectable contamination, and others only having a low level or surface contamination with no detectable airborne viable particles. Our results also indicate that cats were the source of spread of the disease to owners—*M canis*-infected owners were present in seven households, in all of which cats were present and

Table 1. Details of the 21 infected cats and their environments

No.	Breed	Dermatological signs	Woods lamp	Co-habiting pets	Infected owners	Air samples		Surface samples	
						Positive	Score	Positive	Score
1	DSH, 2 ms, Fs	Some crusting papules on the nose	+	None	2 of 3	5/5	HC	10/10	HC
2	DSH, 2 ms, M	Diffuse annular alopecic areas and scales	+	One of one symptomatic dog culture+	2 of 2	5/5	HC	10/10	HC
3	Persian, 4 ys, Mc	Four annular alopecic areas on abdomen	+	Two hamsters asymptomatic and culture−	None	5/5	IC	5/5	IC
4	DSH, 3 ys, Mc	Two annular alopecic areas on pinnae	−	None	None	1/5	LC	0/5	NC
5	DSH, 1 y, F	One annular alopecic area on muzzle	−	Four asymptomatic cats negative on culture	None	0/5	NC	1/10	LC
6	Persian, 2 ys, M	Four annular alopecic areas on neck, dorsum and forelimbs	−	Two of five symptomatic cats culture+	1 of 2	5/5	LC	10/10	IC
7	DSH, 2 ys, Mc	One annular alopecic area on neck	−	None	None	0/5	NC	1/10	LC
8	DSH, 5 ms, F	Crusting papules on head and dorsum, pruritus	−	None	1 of 2	5/5	HC	10/10	HC
9	DSH, 4 ys, Mc	One annular alopecic area on the head	−	None	None	1/5	LC	2/10	LC
10	Persian, 3 ys, M	Scales, seborrhoea and pruritus	−	None	None	0/5	NC	1/10	LC
11	DSH, 6 ms, Fs	Diffuse annular alopecic areas and crusting papules	−	One dog of one asymptomatic negative on culture	None	5/5	HC	10/10	HC
12	DSH, 5 ms, F	Diffuse annular alopecic areas, scales and pruritus	−	None	1 of 1	3/5	LC	6/10	IC
13	DSH, 4 ys, M	Diffuse annular alopecic areas and crusting papules	−	Five of six asymptomatic cats positive on culture	None	3/5	LC	3/10	IC
14	DSH, 1 y, Mc	Diffuse annular alopecic areas and scales	+	One of one asymptomatic cat culture+	2 of 4	5/5	HC	10/10	HC
15	DSH, 4 ms, F	Diffuse annular alopecic areas and scales	−	None	None	5/5	HC	10/10	HC
16	DSH, 2 ys, Mc	Scales, seborrhoea and pruritus	−	One of two asymptomatic cats culture+	None	1/5	IC	3/10	IC
17	Persian, 10 ms, F	Diffuse annular alopecic areas, crusting papules and pruritus	+	One of one asymptomatic cat culture+	2 of 3	5/5	HC	9/10	HC
18	Persian, 8 ms, M	Diffuse annular alopecic areas and crusting papules	−	None	None	5/5	HC	10/10	HC
19	DSH, 2 ys, Fs	Three annular alopecic areas on head and forelimb, seborrhoea	−	None	None	1/5	IC	4/10	IC
20	DSH, 18 ms, Mc	Diffuse annular alopecic areas on head, pinnae, forelimb and hindlimb	+	One of one symptomatic cat culture+	None	3/5	IC	2/10	IC
21	Persian, 12 ys, F	One annular alopecic area on neck	−	None	None	1/5	LC	0/10	NC

DSH=domestic short-haired; ms=months; ys=years; M=male; Mc=male castrated; F=female; Fs=female sterilized.

Table 2. Details of the nine infected dogs and their environments

No.	Breed	Dermatological signs	Woods lamp	Co-habiting pets	Infected owners	Air samples		Surface samples	
						Positive	Score	Positive	Score
1	Collie, 4 ms, F	Two annular alopecic areas on nose and eyelid	–	Three of three asymptomatic dogs culture–	None	0/5	NC	0/10	NC
2	English bulldog, 18 ms, F	Four annular alopecic areas on pinna and neck	–	Two of two asymptomatic dogs culture–	None	0/5	NC	0/10	NC
3	Bassett hound, 3 ys, F	Seborrhoea and scales	–	Three of four symptomatic puppies culture+	None	0/5	NC	0/10	NC
4	American Staffordshire terrier, 17 ms, M	Diffuse annular alopecic areas and crusting papules	+	None	None	0/5	NC	0/10	NC
5	Mongrel, 9 ys, F	Two annular alopecic areas on muzzle	+	None	None	0/5	NC	0/10	NC
6	Dobermann pinscher, 2 ys, M	One annular alopecic area on laeral thorax	–	One of five asymptomatic dogs culture+	None	0/5	NC	2/10	LC
7	Naples's Mastiff, 2 ms, F	Multiple annular alopecic areas on head and forelimb	+	Three of three asymptomatic dogs culture–	None	0/5	NC	1/10	LC
8	Great Dane, 6 ms, F	One annular alopecic area on head	–	One dog and one cat asymptomatic culture–	None	0/5	NC	1/10	LC
9	Boxer, 1 y, M	One annular alopecic area on forelimb	+	None	None	0/5	NC	2/10	LC

ms=months; ys=years; M=male; F=female.

no infected owners were found in households with infected dogs (although there was one household that had an infected cat and an asymptomatic dog that was culture-positive and ascribed to passive contamination). These data are interesting, although the small number of dogs included in the study suggests that some caution should be used in the interpretation of these results.

The age of the cats also seemed to be of relevance when evaluating human infection, as kittens were more frequently involved, being present in the households in six of seven cases of human infection. In the one house with an adult cat (2 years of age) and concomitant human infection (#6, Table 1), the cat was not a pet but part of a cattery and had contact with other cats roaming free in the shelter. The cat had extensive lesions, and two of five co-habiting cats were both symptomatic and culture-positive. This case illustrates the difficulty in managing dermatophytosis in multi-cat environments, and also the potential human health hazards in this situation (Moriello 1990). The seven human infections were from five heavily contaminated households, and in two intermediate-contaminated households.

From our results, of the 21 symptomatic *M canis*-infected cats, six were long-haired and 15 were short-haired. The sample size was too small to draw any general conclusions from this although it is widely held that long-haired cats are predisposed to develop dermatophytosis.

Although the small number of canine cases again precludes any firm conclusions, the role of this species in the spreading of arthrospores should not be underestimated. Although environmental contamination was absent or present at low levels in households with infected dogs, a case of co-infection in puppies, and a carrier dog, was found in two different households illustrating the potential for the disease to spread.

We found no obvious difference in the number of fungal colonies obtained from 'soft' and 'hard' surface samples, despite the latter being more amenable to routine household cleaning. Thus our study suggested that airborne dispersal of arthrospores contaminated all surfaces continuously.

We found that households with an intermediate level of surface contamination had less consistent culture results, and had intermediate or low levels of airborne contamination. In contrast, households classified as having a low contamination level invariably had only 1 CFU/plate present on culture. The presence of a very low number of spores in the environment has practical relevance, as a minimum number of spores (although undefined) along with other factors, would be required to cause infection and establish clinical disease.

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