

AperTO - Archivio Istituzionale Open Access dell'Università di Torino

**Advances in Microbiology, Infectious Diseases and Public Health: Fungal Occurrence in the Hair and Skin of Symptomatic Pets in Turin, Italy [A.M.Cuffini is the corresponding author]**

**This is the author's manuscript**

*Original Citation:*

*Availability:*

This version is available <http://hdl.handle.net/2318/1559866> since 2025-07-09T07:16:35Z

*Publisher:*

Springer International Publishing Swizerland 2015

*Published version:*

DOI:10.1007/5584\_2015\_5004

*Terms of use:*

Open Access

Anyone can freely access the full text of works made available as "Open Access". Works made available under a Creative Commons license can be used according to the terms and conditions of said license. Use of all other works requires consent of the right holder (author or publisher) if not exempted from copyright protection by the applicable law.

(Article begins on next page)

## Metadata of the chapter that will be visualized online

Chapter Title	Advances in Microbiology, Infectious Diseases and Public Health: Fungal Occurrence in the Hair and Skin of Symptomatic Pets in Turin, Italy
Chapter Sub Title	Fungi in Pets
Copyright Year	2015
Copyright Holder	Springer International Publishing Switzerland
Author	Family Name <b>Allizond</b> Particle Given Name <b>Valeria</b> Suffix Division Department of Public Health and Pediatrics, Bacteriology and Mycology Laboratory Organization University of Torino Address Via Santena 9, 10126 Turin, Italy
Author	Family Name <b>Tullio</b> Particle Given Name <b>Vivian</b> Suffix Division Department of Public Health and Pediatrics, Bacteriology and Mycology Laboratory Organization University of Torino Address Via Santena 9, 10126 Turin, Italy
Corresponding Author	Family Name <b>Cuffini</b> Particle Given Name <b>Anna Maria</b> Suffix Division Department of Public Health and Pediatrics, Microbiology Section Organization University of Torino Address Via Santena 9, 10126 Turin, Italy Email <a href="mailto:annamaria.cuffini@unito.it">annamaria.cuffini@unito.it</a>
Author	Family Name <b>Roana</b> Particle Given Name <b>Janira</b> Suffix Division Department of Public Health and Pediatrics, Bacteriology and Mycology Laboratory Organization University of Torino Address Via Santena 9, 10126 Turin, Italy

---

Author                      Family Name    **Scalas**  
Particle  
Given Name    **Daniela**  
Suffix  
Division            Department of Public Health and Pediatrics, Bacteriology  
and Mycology Laboratory  
Organization    University of Torino  
Address            Via Santena 9, 10126 Turin, Italy


---

Author                      Family Name    **Marra**  
Particle  
Given Name    **Elisa Simona**  
Suffix  
Division            Department of Public Health and Pediatrics, Bacteriology  
and Mycology Laboratory  
Organization    University of Torino  
Address            Via Santena 9, 10126 Turin, Italy

---

Author                      Family Name    **Piersigilli**  
Particle  
Given Name    **Giorgia**  
Suffix  
Division            Department of Public Health and Pediatrics, Bacteriology  
and Mycology Laboratory  
Organization    University of Torino  
Address            Via Santena 9, 10126 Turin, Italy

---

 Author                      Family Name    **Mandras**  
Particle  
Given Name    **Narcisa**  
Suffix  
Division            Department of Public Health and Pediatrics, Bacteriology  
and Mycology Laboratory  
Organization    University of Torino  
Address            Via Santena 9, 10126 Turin, Italy

---

Author                      Family Name    **Banche**  
Particle  
Given Name    **Giuliana**  
Suffix  
Division            Department of Public Health and Pediatrics, Bacteriology  
and Mycology Laboratory  
Organization    University of Torino

Address Via Santena 9, 10126 Turin, Italy

---

Abstract

Companion animals, often asymptomatic *reservoir* of fungi, can be important sources of infection in humans, due to the close contact with their owners. The present study was aimed to assess the occurrence of dermatophytes and other fungi isolated from pet dermatological lesions in Turin, Italy. Dermatological specimens were examined for fungal elements by direct microscopy and cultured to detect dermatophytes, other filamentous fungi and yeasts: 247 pets (118 cats, 111 dogs and 18 dwarf rabbits) were positive for fungal detection in culture. *Microsporum canis* was the most frequent dermatophyte in cats and dogs, whereas *Trichophyton mentagrophytes* was the most common in rabbits. Among the other fungi, for all examined pets, dematiaceous fungi were the most isolated, followed by *Mucorales*, penicilli, yeasts and yeast-like fungi, and aspergilli. No gender predisposition was detected for dermatophyte growth; on the contrary, for the other fungi male cats were more susceptible than female. The highest fungal occurrence was recorded in <1-year-old cats for dermatophytes, and in <5-year-old cats and dogs for the other fungi. Autumn was the period associated with a relevant incidence of fungal infection. Finally, fungi were more frequent in non pure-breed cats and in pure-breed dogs. These data underline the importance to timely inform pet owners about the potential health risk of infection caused not only by dermatophytes but also by non-dermatophyte fungi, routinely considered to be contaminants or harmless colonizers, since their role as source of zoonotic infections is not to be excluded.

---

Keywords (separated  
by '-')

Dermatophytes - Non-dermatophyte fungi - Pets - Hair and skin lesions

---

4  
5 **Advances in Microbiology, Infectious**  
6 **Diseases and Public Health: Fungal**  
7 **Occurrence in the Hair and Skin**  
8 **of Symptomatic Pets in Turin, Italy**

9 **Valeria Allizond\*, Vivian Tullio\*, Anna Maria Cuffini,**  
10 **Janira Roana, Daniela Scalas, Elisa Simona Marra,**  
11 **Giorgia Piersigilli, Marcisa Mandras, and Giuliana Banche**

12 **Abstract**

13 Companion animals, often asymptomatic *reservoir* of fungi, can be  
14 important sources of infection in humans, due to the close contact with  
15 their owners. The present study was aimed to assess the occurrence of  
16 dermatophytes and other fungi isolated from pet dermatological lesions  
17 in Turin, Italy. Dermatological specimens were examined for fungal  
18 elements by direct microscopy and cultured to detect dermatophytes,  
19 other filamentous fungi and yeasts: 247 pets (118 cats, 111 dogs and  
20 18 dwarf rabbits) were positive for fungal detection in culture.  
21 *Microsporium canis* was the most frequent dermatophyte in cats and  
22 dogs, whereas *Trichophyton mentagrophytes* was the most common in  
23 rabbits. Among the other fungi, for all examined pets, dematiaceous  
24 fungi were the most isolated, followed by *Mucorales*, penicilli, yeasts  
25 and yeast-like fungi, and aspergilli. No gender predisposition was  
26 detected for dermatophyte growth; on the contrary, for the other fungi  
27 male cats were more susceptible than female. The highest fungal occur-  
28 rence was recorded in <1-year-old cats for dermatophytes, and in <5-  
29 year-old cats and dogs for the other fungi. Autumn was the period  
30 associated with a relevant incidence of fungal infection. Finally, fungi  
31 were more frequent in non pure-breed cats and in pure-breed dogs. These  
32 data underline the importance to timely inform pet owners about the  
33 potential health risk of infection caused not only by dermatophytes but

V. Allizond\*, V. Tullio\*, J. Roana, D. Scalas, E.S. Marra,  
G. Piersigilli, N. Mandras, and G. Banche

Department of Public Health and Pediatrics, Bacteriology  
and Mycology Laboratory, University of Torino, Via  
Santena 9, 10126 Turin, Italy

A.M. Cuffini (✉)

Department of Public Health and Pediatrics,  
Microbiology Section, University of Torino, Via Santena  
9, 10126 Turin, Italy  
e-mail: [annamaria.cuffini@unito.it](mailto:annamaria.cuffini@unito.it)

34 also by non-dermatophyte fungi, routinely considered to be contaminants  
 35 or harmless colonizers, since their role as source of zoonotic infections is  
 36 not to be excluded.

**Keywords**

Dermatophytes • Non-dermatophyte fungi • Pets • Hair and skin lesions

**39 1 Introduction**

40 Considering the close contact between pets and  
 41 their owners, especially between children and  
 42 cats and dogs, these animals, often asymptomatic  
 43 carries of dermatophytes, can be important  
 44 sources of infection and/or carriers of infection  
 45 (Mattei et al. 2014). In addition, evidence exists  
 46 that rodents, such as rabbits, may be a risk of  
 47 infection for their owners and for those who work  
 48 closely with them (Torres-Rodríguez et al. 1992;  
 49 Hata et al. 2000; Spiewak and Szostak 2000). It is  
 50 widely known that animals are the *reservoir* of  
 51 many dermatophytes belonging to the genera  
 52 *Microsporium* spp. and *Trichophyton* spp., and  
 53 that dermatophytoses are usually disseminated  
 54 among domestic animals. *M. canis*, *M. gypseum*  
 55 and *T. mentagrophytes* are the main etiological  
 56 agents of clinical dermatophytosis in pets (Bond  
 57 2010; Kraemer et al. 2012). The disease is  
 58 characterized by alopecia, scaling and crusting;  
 59 however, other filamentous fungi could mimic  
 60 dermatophyte lesions rendering them indistin-  
 61 guishable from that of dermatophytes. These  
 62 non-dermatophytic fungi isolated from animal  
 63 lesions could have pathogenic potential and/or  
 64 keratinolytic activity. In fact many of these spe-  
 65 cies, such as *Alternaria* spp., *Scopulariopsis* spp.,  
 66 *Penicillium* spp., *Rhizopus* spp. and *Fusarium*  
 67 spp., are reported to be involved in fungal disease  
 68 development and are increasingly recognized as  
 69 agent of diseases both in animals and humans  
 70 (Aho 1983; Bagy and Abdel-Mallek 1991;  
 71 Seyedmousavi et al. 2015). Therefore, the  
 72 aim of this report was to determine the occur-  
 73 rence, in Turin (Italy), of dermatophyte and  
 74 non-dermatophyte fungi from living indoor cats,  
 75 dogs and dwarf rabbits with lesions, referable to

mycoses, for health monitoring since they are out 76  
 by an appropriate health check. 77

**2 Animals and Methods 78**

**2.1 Animals 79**

In the period between March 2007 and 80  
 November 2014, clinical dermatological 81  
 specimens from 362 indoor domestic animals 82  
 (195 cats, 149 dogs and 18 dwarf rabbits) were 83  
 collected at Veterinary Clinics located in Turin. 84  
 Pets, with suspected dermatophytosis, presented 85  
 dermatological clinical signs such as scales, fol- 86  
 liculitis, crusts and alopecic areas with variable 87  
 degrees of inflammation and itch. Specimens 88  
 (hair, scaling, crusts and/or skin scraping) were 89  
 taken from head, abdomen, back and legs using 90  
 a sterile lancet or pliers. The samples were sub- 91  
 mitted to the Bacteriology and Mycology Labo- 92  
 ratory, Department of Public Health and 93  
 Pediatrics, University of Torino, Turin, and 94  
 processed. 95

**2.2 Epidemiological Data 96  
 Collection 97**

The age, sex, breed, habitat in which animals 98  
 lived and the presence of clinical signs were 99  
 recorded for each animal. To assess the seasonal 100  
 pattern of fungal infections, the sampling period 101  
 was divided into four groups: spring (March– 102  
 May), summer (June–August), autumn 103  
 (September–November) and winter 104  
 (December–February). 105

### 106 **2.3 Fungal Isolation** 107 **and Identification**

108 Specimens were examined for fungal elements by  
109 direct microscopy at 400× magnification after  
110 imbibitions in 20 % KOH. Multiple *inocula*  
111 (at least five) of the clinical specimens were  
112 cultured on Mycosel agar (MYC; Merck,  
113 Germany) to detect dermatophytes and Sabouraud  
114 dextrose agar (SAB; Sigma, St. Louis, Mo) for  
115 other filamentous fungi and yeasts. If the lesions  
116 were treated with antimycotics or covered in pus  
117 or other materials, they were first carefully  
118 washed with soap and water. The plates were  
119 incubated at 25 °C for at least 4 weeks and exam-  
120 ined twice weekly. Cultures were held for at least  
121 4 weeks before being considered negative. Each  
122 developing colony was isolated in pure culture on  
123 the following media: MYC (dermatophytes),  
124 Czapek's dox agar (Merck; aspergilli and  
125 penicillia), Potato dextrose agar (Merck; *Fusar-*  
126 *ium* spp.), modified Dixon agar (Merck;  
127 *Malassezia* spp.) and SAB (other filamentous  
128 fungi, yeasts and yeast-like fungi). The filamen-  
129 tous fungi, *Malassezia pachydermatis* and the  
130 yeast-like fungi were identified according to  
131 their colonial morphology and the microscopic  
132 appearance of the fungal elements (Raper and  
133 Fennell 1965; Rebell and Taplin 1979; Ellis  
134 1993; Gueho et al. 1996; Guillot et al. 1996; de  
135 Hoog et al. 2000; Pitt 2000), whereas the yeasts  
136 were identified by API ID 32C (bioMérieux Italia  
137 S.p.A.; Italy).

### 138 **2.4 Statistical Analysis**

139 The chi-square test was performed for the analy-  
140 sis associations of the categorized variables: sex,  
141 age, season and breed. A  $p$  value of  $<0.05$  was  
142 considered significant.

## 143 **3 Results**

144 This study included 362 symptomatic pets with  
145 marked skin lesions, characterized by alopecic

146 areas, more or less itching, scabbed, disseminated 146  
147 in several body regions (head, abdomen, back, 147  
148 legs; data not shown), indistinguishable between 148  
149 dermatophytic and non-dermatophytic ones. 149

150 Out of 362 domestic animals, 282 were posi- 150  
151 tive for fungal elements at direct examination and 151  
152 247 were positive for fungal detection in culture 152  
153 (118 cats, 111 dogs and all 18 dwarf rabbits; 153  
154 Table 1). 54.25 % of cat samples, 38.75 % of 154  
155 dog samples and 27.78 % of rabbit samples 155  
156 were positive for dermatophytes: *M. canis* was 156  
157 the most frequent dermatophyte isolated from 157  
158 cats and dogs, whereas *M. gypseum* and 158  
159 *T. mentagrophytes* were isolated from 2 dogs 159  
160 and 5 rabbits, respectively. 160

161 The remaining fungal cultures (54.66%; Table 1) 161  
162 were positive for other filamentous fungi and yeasts. 162  
163 In details: dematiaceous (*Alternaria alternata*, 163  
164 *Epicoccum nigrum*, *Cladosporium cladosporioides*, 164  
165 *C. sphaerospermum*, *C. herbarum*, *Aureobasidium*  
166 *pullulans* and *Nigrospora* spp.) for 34.44 %; hyaline 166  
167 mycetes, represented by penicilli (*Penicillium*  
168 *brevi-compactum*, *P. griseofulvum*, *P. waksmanii*), 168  
169 aspergilli (*Aspergillus niger*, *A. versicolor* and 169  
170 *A. fumigatus*), *Trichoderma harzianum*, *T. viride*  
171 and *Fusarium* spp. for 10.11 %; *Mucorales*,  
172 represented by *Rhizopus oryzae* and *Mucor*  
173 *hiemalis*, for 6.07 %; yeasts and yeast-like fungi,  
174 represented by *Candida* spp., *M. pachydermatis* and  
175 *Geotrichum candidum*, for 4.04 %. 175

176 In all positive animals, males were more than 176  
177 females (Table 2); however no gender predispo- 177  
178 sition was detected for dermatophyte growth; on 178  
179 the contrary, male cats were significantly 179  
180 ( $p = 0.0224$ ) more susceptible than female for 180  
181 other fungi. It can be highlighted the highest 181  
182 dermatophyte occurrence in  $<1$ -year-old cats 182  
183 ( $p < 0.0001$ ) and the presence of other fungi in 183  
184  $<5$ -year-old positive cats ( $p < 0.0001$ ) and dogs 184  
185 ( $p = 0.0276$ ; Table 2). All positive rabbits were 185  
186 less than 1-year-old. Positive samples for 186  
187 dermatophytes and other fungi were recorded in 187  
188 autumn (September–November) for all compan- 188  
189 ion animals: a significant seasonal difference was 189  
190 detected for dogs ( $p = 0.0168$ ; Table 2). Finally, 190  
191 fungi were more frequent in pure-breed dogs and 191  
192 in non pure-breed cats (Table 2), without statisti- 192  
193 cal significant differences. 193

t.1 **Table 1** Isolation and occurrence of fungal species (%)

t.2	Cats		Dogs		Rabbits		Total		
t.3	118/195 <sup>a</sup>		111/149		18/18		247/362		
t.4	(60.51 %)		(74.50 %)		(100 %)		(68.23 %)		
t.5	Positive animals examined								
t.6	n	%	n	%	n	%	n	%	
t.7	<b>Dermatophytes</b>								
t.8	<i>Microsporium canis</i>	64	54.25	41	36.95	–	–	105	42.51
t.9	<i>M. gypsum</i>	–	–	2	1.80	–	–	2	0.81
t.10	<i>Trichophyton mentagrophytes</i>	–	–	–	–	5	27.78	5	2.02
t.11	<b>Total</b>	<b>64</b>	<b>54.25</b>	<b>43</b>	<b>38.75</b>	<b>5</b>	<b>27.78</b>	<b>112</b>	<b>45.34</b>
t.12	<b>Dematiaceous mycetes</b>								
t.13	<i>Alternaria alternata</i>	16	13.56	18	16.22	–	–	34	13.78
t.14	<i>Epicoccum nigrum</i>	11	9.32	14	12.61	–	–	25	10.12
t.15	<i>Cladosporium cladosporioides</i>	5	4.24	7	6.31	–	–	12	4.87
t.16	<i>C. sphaerospermum</i>	2	1.69	2	1.80	–	–	4	1.62
t.17	<i>C. herbarum</i>	–	–	2	1.80	–	–	2	0.81
t.18	<i>Aureobasidium pullulans</i>	–	–	2	1.80	4	22.22	6	2.43
t.19	<i>Nigrospora</i> spp.	2	1.69	–	–	–	–	2	0.81
t.20	<b>Total</b>	<b>36</b>	<b>30.50</b>	<b>45</b>	<b>40.54</b>	<b>4</b>	<b>22.22</b>	<b>85</b>	<b>34.44</b>
t.21	<b>Hyaline mycetes</b>								
t.22	<i>Penicillium brevi-compactum</i>	5	4.24	2	1.80	4	22.22	11	4.46
t.23	<i>P. griseofulvum</i>	1	0.85	–	–	–	–	1	0.40
t.24	<i>P. waksmanii</i>	–	–	2	1.80	–	–	2	0.81
t.25	<i>Aspergillus niger</i>	2	1.69	–	–	–	–	2	0.81
t.26	<i>A. versicolor</i>	–	–	1	0.90	–	–	1	0.40
t.27	<i>A. fumigatus</i>	–	–	4	3.61	–	–	4	1.62
t.28	<i>Trichoderma harzianum</i>	1	0.85	–	–	–	–	1	0.40
t.29	<i>T. viride</i>	1	0.85	–	–	–	–	1	0.40
t.30	<i>Fusarium</i> spp.	–	–	2	1.80	–	–	2	0.81
t.31	<b>Total</b>	<b>10</b>	<b>8.48</b>	<b>11</b>	<b>9.91</b>	<b>4</b>	<b>22.22</b>	<b>25</b>	<b>10.11</b>
t.32	<b>Zygomycetes</b>								
t.33	<i>Rhizopus oryzae</i>	3	2.54	5	4.50	5	27.78	13	5.26
t.34	<i>Mucor hiemalis</i>	2	1.69	–	–	–	–	2	0.81
t.35	<b>Total</b>	<b>5</b>	<b>4.23</b>	<b>5</b>	<b>4.50</b>	<b>5</b>	<b>27.78</b>	<b>15</b>	<b>6.07</b>
t.36	<b>Yeasts and yeast-like fungi</b>								
t.37	<i>Candida tropicalis</i>	1	0.85	–	–	–	–	1	0.40
t.38	<i>C. albicans</i>	–	–	2	1.80	–	–	2	0.81
t.39	<i>Malassezia pachydermatis</i>	2	1.69	3	2.70	–	–	5	2.02
t.40	<i>Geotrichum candidum</i>	–	–	2	1.80	–	–	2	0.81
t.41	<b>Total</b>	<b>3</b>	<b>2.54</b>	<b>7</b>	<b>6.30</b>	–	–	<b>10</b>	<b>4.04</b>

t.42 <sup>a</sup>Positive/total; n = number of cases of isolation; % = percentage frequency of occurrence (calculated per number of positive animals sampled)

## 194 4 Discussion

195 Over the past two decades, studies of  
 196 dermatophytoses from domestic or wild animals  
 197 have been described worldwide (Brilhante

et al. 2003; Khosravi and Mahmoudi 2003; 198  
 Cafarchia et al. 2004; Bond 2010; Kraemer 199  
 et al. 2012). In some countries, such as Italy 200  
 and France, *M. canis* is the most common etio- 201  
 logical agent, whereas in Spain it varies in rela- 202  
 tion to the geographical area (Torres-Rodríguez 203

**Table 2** Prevalence of dermatophytes and other fungi in cats, dogs and rabbits in relation to epidemiological variables<sup>a</sup>

	Cats			Dogs			Rabbits			
	Dermatophytes	Other fungi		Dermatophytes	Other fungi		Dermatophytes	Other fungi		
	Positivity/n	%	Positivity/n	%	Positivity/n	%	Positivity/n	%	Positivity/n	
<b>Sex</b>										
Male	34/121	28.10	39/121	32.23	24/85	28.23	39/85	45.88	13/13	100
Female	30/74	40.54	15/74	20.27	19/64	29.69	29/64	45.31	5/5	100
	<b>p = 0.0224</b>			<b>p = 0.7867</b>			<b>p &lt; 0.0001</b>			
<b>Age</b>										
< 1 year	41/96	42.71	17/96	17.71	22/62	35.48	24/62	38.71	5/18	27.78
1–5 years	16/81	19.75	33/81	40.74	9/45	20.0	25/45	55.55	–	–
> 5 years	7/18	38.89	4/18	22.22	12/42	28.57	19/42	45.24	–	–
	<b>p &lt; 0.0001</b>			<b>p = 0.0276</b>			N.A.			
<b>Seasons</b>										
Spring	14/38	36.84	9/38	23.68	4/21	19.04	12/21	57.14	–	4/4
Summer	4/15	26.67	5/15	33.33	7/23	30.43	10/23	43.48	–	–
Autumn	32/101	31.68	29/101	28.71	22/78	28.21	36/78	46.15	5/5	100
Winter	14/41	34.15	11/41	26.83	10/27	37.04	10/27	37.04	–	9/9
	<b>p = 0.3695</b>			<b>p = 0.0168</b>			N.A.			
<b>Breed</b>										
Cross-breed	–	–	–	–	15/39	38.46	14/39	35.90	–	–
Pure-breed	23/59	38.98	13/59	22.03	28/110	25.45	54/110	49.09	5/18	27.78
Other breed	41/136	30.15	41/136	30.15	–	–	–	–	–	–
	<b>p = 0.1216</b>			<b>p = 0.1216</b>			N.A.			

<sup>a</sup>The chi-square test was used for the analysis associations of the categorized variables: sex, age, season and breed  
A *p* value of <0.05 was considered significant

204 et al. 1992). In our study (Table 1) *M. canis* was  
205 the most frequent dermatophyte isolated in cats  
206 and dogs, confirming previous reports in Turin  
207 and in other sites in Italy, indicating that this  
208 fungus did not vary over the years (Marchisio  
209 et al. 1995; Mantovani 1978; Chermette  
210 et al. 2008; Bond 2010); *M. gypseum* and  
211 *T. mentagrophytes* were isolated from dogs and  
212 rabbits, respectively, underlying that these  
213 dermatophytes affect other pets (Chermette  
214 et al. 2008; Bond 2010). Additionally, our data  
215 report 5 *M. canis* isolated from asymptomatic  
216 cats (data not shown) whose owners manifested  
217 skin mycoses, indicating that cats are at present  
218 recognized as major sources of infection for their  
219 owners, confirming literature data (Cafarchia  
220 et al. 2006). As reported by Bond (2010), asymp-  
221 tomatic carriers cats are especially risky for  
222 humans, because no precautions are taken to  
223 prevent potential transfer; however, such cats  
224 may progress to develop overt infection and  
225 more abundant arthroconidia shedding. Infected  
226 cats have been shown to cause substantial envi-  
227 ronmental contamination and a significant air-  
228 borne load of viable fungal elements, whereas  
229 dogs are of lesser importance in this regard.

230 Other filamentous fungi are common in the  
231 environment and their conidia are transported by  
232 air currents and settled on pet fur. Among these  
233 moulds, dematiaceous fungi and *Fusarium* spp.,  
234 isolated in this study (Table 1), are nowadays  
235 well recognized as etiological agents of mycosis  
236 in animals and humans too (Bagy and Abdel-  
237 Mallek 1991; Noble et al. 1997; Huttova  
238 et al. 1998; Kluger et al. 2004; Walsh  
239 et al. 2004; Sanchez and Larsen 2007; Fan  
240 et al. 2009; Ryoo et al. 2009). For example, a  
241 case of *Alternaria* peritonitis after contact with a  
242 cat and the involvement in pet skin infections of  
243 *Fusarium* spp., a well-recognized cause of  
244 human diseases, were reported (Kluger  
245 et al. 2004; Ryoo et al. 2009). In this study  
246 *Alternaria*, *Epicoccum*, *Cladosporium* and  
247 *Fusarium* isolates probably played a role in the  
248 pathogenicity: they were no sporadic and many  
249 colonies were seen on the plates in each case.

250 Furthermore, we isolated some saprophytic  
251 fungi, commonly found in air and soil, such as

*Mucorales* besides penicillin and aspergilli 252  
(Table 1). Albeit the recovery of these fungi 253  
was consistent with the findings of other authors 254  
(Bagy and Abdel-Mallek 1991; Keller 255  
et al. 2000; Efuntoye and Fashanu 2002; 256  
Ledbetter et al. 2007), further studies are 257  
required to verify and confirm their pathogenesis 258  
in companion animals. 259

*Trichoderma* spp., a saprophytic fungus com- 260  
monly found in soil, isolated only from a cat in 261  
our study, has been reported among emerging 262  
fungal pathogens for both animals and humans 263  
(Table 1) (Kluger et al. 2004; Kantarcioğlu 264  
et al. 2009). 265

From a veterinary point of view, our findings 266  
related to the yeast *M. pachydermatis* from cat 267  
and dog skin lesions may have a great signifi- 268  
cance (Table 1). It can be found in very large 269  
proportion on the skin of healthy animals and it is 270  
the only lipid-independent species in the genus 271  
*Malassezia*; however since the early 1990s 272  
*M. pachydermatis* was isolated from lesions of 273  
atopic dermatitis, flea allergic dermatitis, otitis 274  
externa, pyoderma and seborrheic dermatitidis in 275  
dogs and cats (Aizawa et al. 2001; Dorogi 2002; 276  
Khosravi et al. 2010). Although 277  
*M. pachydermatis* is not normally isolated from 278  
human skin, there have been several reports of 279  
*M. pachydermatis*-associated fungaemia in 280  
infants in neonatal intensive care unit and in 281  
adults with serious internal diseases (Bond 282  
et al. 2010; ESCCAP Guideline 2011). 283

Literature data on sex, age, seasonality and 284  
breed are still controversial (Khosravi and 285  
Mahmoudi 2003; Cafarchia et al. 2004; Cabanes 286  
et al. 1997). With regard to the sex, from our 287  
results, in both cats and dogs no significant dif- 288  
ference between the sexes for dermatophyte 289  
growth has been detected. Among cats, males 290  
were significantly more susceptible than females 291  
to other fungi occurrence (Table 2); this may be 292  
accounted for a different composition of sebum 293  
between males and females, as suggested by 294  
Cafarchia et al. (2004). For age, our data show 295  
that young animals are more susceptible to fun- 296  
gal infections (Table 2). Adult animals tend to be 297  
more resistant to infections than young animals 298  
in relation to their changes in the skin and 299

300 secretions (quantity and nature of sebaceous  
 301 lipids in the epidermis), hair replacement cycle,  
 302 and development of an immune response to  
 303 keratinophylic moulds (Bond 2010; Cafarchia  
 304 et al. 2004; Rotstein et al. 1999; Khosravi and  
 305 Mahmoudi 2003). Although the risk of dermato-  
 306 phyte infection is greater for puppies, kittens and  
 307 aged or debilitated animals, the infection is not  
 308 strictly age or health status-related, and so the  
 309 risk continues throughout life. Consideration  
 310 should be given to provide all dogs and cats  
 311 with appropriate dermatophyte control through-  
 312 out their lives (ESCCAP Guideline 2011). From  
 313 our study autumn was the period with the highest  
 314 risk for fungal infection (Table 2), according to  
 315 Mancianti et al. (2002) and Iorio et al. (2007).  
 316 The prevalence of non-dermatophyte and derma-  
 317 tophyte filamentous fungi varies according to the  
 318 climate, temperature, relative humidity and rain-  
 319 fall of different geographical regions or natural  
 320 reservoir (Brilhante et al. 2003; Cabanes  
 321 et al. 1997; Mancianti et al. 2002; Iorio  
 322 et al. 2007). Moreover, the life style such as the  
 323 tendency to live in the outdoor environment in  
 324 contact with soil, in groups, in isolation or in  
 325 proximity to humans; the hygiene; the  
 326 differences in non-specific cutaneous defenses  
 327 are the general conditions related to the higher  
 328 prevalence of fungal infections (de Hoog  
 329 et al. 2000; Brilhante et al. 2003; Cafarchia  
 330 et al. 2006). In our study in both cats and dogs  
 331 there was difference in fungal isolation related to  
 332 breed since fungi were more frequent in non  
 333 pure-breed cats and in pure-breed dogs  
 334 ( $p < 0.05$ ; Table 2). Actually, breed is not  
 335 proved to be a predisposing factor for infection  
 336 (Cafarchia et al. 2006; Mancianti et al. 2002).  
 337 “The disease is not clear, unless we seek it”:  
 338 contact with animals or contaminated  
 339 environments represents the major risk of infec-  
 340 tion for humans and people in contact with  
 341 infected animals should be advised of the risk.  
 342 In fact, nowadays, lack of connection between  
 343 the monitoring of diseases in animals and  
 344 humans is still great. The best way to bypass  
 345 infection is to prevent the contact: this prophyl-  
 346 actic strategy is very simple but not always  
 347 feasible because infected animals do not show

obvious clinical signs. When lesions are evident, 348  
 the dermatophyte clinical lesion appearance is 349  
 often indistinguishable from that caused by 350  
 other fungi, suggesting the need for greater and 351  
 accurate control, monitoring and identification of 352  
 these last species to avoid the overestimated 353  
 clinical diagnosis of dermatophytoses and to 354  
 address the appropriate therapy. The role of 355  
 animals as source of zoonoses in dermatophyte 356  
 is widely accepted; on the contrary further 357  
 investigations to evaluate the considerable zoo- 358  
 notic and zoopathogenic potential of other fungi, 359  
 routinely considered to be contaminants or harm- 360  
 less colonizers, are necessary. A better under- 361  
 standing of diseases in pets could have direct 362  
 relevance for the prevention and the fight against 363  
 infectious diseases of humans. 364

**Acknowledgments** The authors are indebted to 365  
 Dr. Gianmario Baralis and Dr. Rosanna Barbero (Veteri- 366  
 nary Clinics) for providing pet samples. 367





## References 368

- Aho R (1983) Saprophytic fungi isolated from the hair of 369  
 domestic and laboratory animals with suspected 370  
 dermatophytosis. *Mycopathologia* 83:65–73 371
- Aizawa T, Kano R, Nakamura Y et al (2001) The genetic 372  
 diversity of clinical isolates of *Malassezia* 373  
*pachydermatis* from dogs and cats. *Med Mycol* 374  
 39:329–334 375
- Bagy MM, Abdel-Mallek AY (1991) Saprophytic and 376  
 keratinolytic fungi associated with animals hair from 377  
 Riyadh, Saudi Arabia. *Zentralbl Mikrobiol* 378  
 146:305–310 379
- Bond R (2010) Superficial veterinary mycoses. *Clin* 380  
*Dermatol* 28:226–236 381
- Bond R, Guillot J, Cabanes J et al (2010) *Malassezia* 382  
 yeasts in animal diseases. In: Boekhout T, Guého- 383  
 Kellermann E, Maysner P, Velegraki A (eds) 384  
*Malassezia and the skin*. Springer, Berlin, pp 271–299 385
- Brilhante RS, Cavalcante CS, Soares-Junior FA 386  
 et al (2003) High rate of *Microsporum canis* feline 387  
 and canine dermatophytoses in Northeast Brazil: epi- 388  
 demiological and diagnostic features. *Mycopathologia* 389  
 156:303–308 390
- Cabanes FJ, Abarca ML, Bragulat MR (1997) 391  
 Dermatophytes isolated from domestic animals in 392  
 Barcelona, Spain. *Mycopathologia* 137:107–113 393
- Cafarchia C, Romito D, Sasanelli M et al (2004) The 394  
 epidemiology of canine and feline dermatophytoses 395  
 in southern Italy. *Mycoses* 47:508–513 396

- 397 Cafarchia C, Romito D, Capelli G et al (2006) Isolation of  
398 *Microsporum canis* from the hair coat of pet dogs and  
399 cats belonging to owners diagnosed with *M. canis*  
400 tinea corporis. *Vet Dermatol* 17:327–331
- 401 Chermette R, Ferreiro L, Guillot J (2008)  
402 Dermatophytoses in animals. *Mycopathologia*  
403 166:385–405
- 404 de Hoog GS, Gene J, Figueras MJ et al (2000) Atlas of  
405 clinical fungi, 2nd edn. Centraalbureau voor  
406 Schimmelcultures, Utrecht
- 407 Dorogi J (2002) Pathological and clinical aspects of the  
408 diseases caused by *Malassezia* species. *Acta*  
409 *Microbiol Immunol Hung* 29:363–369
- 410 Efuntoye MO, Fashanu SO (2002) Fungi isolated from  
411 skins and pens of healthy animals in Nigeria.  
412 *Mycopathologia* 153:21–23
- 413 Ellis MB (1993) Dematiaceous hyphomycetes. Interna-  
414 tional Mycological Institute, Wallingford
- 415 European Scientific Counsel Companion Animal  
416 Parasites (ESCCAP) (2011) The Mews Studio,  
417 Portland Road Malvern, Worcestershire, United King-  
418 dom. WR14 2TA. First Published by ESCCAP 2011
- 419 Fan YM, Huang WM et al (2009) Onychomycosis caused  
420 by *Nigrospora sphaerica* in an immunocompetent  
421 man. *Arch Dermatol* 145:611–612
- 422 Gueho E, Midgley G et al (1996) The genus *Malassezia*  
423 with description of 4 new species. *Antonie Van*  
424 *Leeuwenhoek* 69:337–355
- 425 Guillot J, Gueho E et al (1996) Identification of  
426 *Malassezia* species. A practical approach. *J Mycol*  
427 *Med* 6:103–110
- 428 Hata Y, Amagai M, Naka W et al (2000) Two cases of  
429 *Trichophyton mentagrophytes* infection contracted  
430 from a hamster and a chinchilla. *Nippon Ishinkin*  
431 *Gakkai Zasshi* 41:269–273
- 432 Huttova M, Kralinsky K, Horn J et al (1998) Prospective  
433 study of nosocomial fungal meningitis in children-  
434 report of 10 cases. *Scand J Infect Dis* 30:485–487
- 435 Iorio R, Cafarchia C, Capelli G et al (2007)  
436 Dermatophytoses in cats and humans in central Italy:  
437 epidemiological aspects. *Mycoses* 50:491–495
- 438 Kantarcioğlu AS, Celkan T, Yücel A et al (2009) Fatal  
439 *Trichoderma harzianum* infection in a leukemic pedi-  
440 atric patient. *Med Mycol* 47:207–215
- 441 Keller M, Krehon S, Stanek C et al (2000) Keratino-  
442 pathogenic mould fungi and dermatophytes in healthy  
443 and diseased hooves of horses. *Vet Rec* 147:619–922
- 444 Khosravi AR, Mahmoudi M (2003) Dermatophytes  
445 isolated from domestic animals in Iran. *Mycoses*  
446 46:222–225
- 447 Khosravi AR, Shokri H, Rad MA et al (2010) Occurrence  
448 of *Malassezia* species in Persian and domestic short  
449 hair cats with and without otitis externa. *J Vet Med Sci*  
450 72:293–296
- 451 Kluger EK, Della Torre PK, Martin P et al (2004) Con-  
452 current *Fusarium chlamydosporum* and  
*Microsphaeropsis arundinis* infections in a cat. *J*  
453 *Feline Med Surg* 6:271–277 454
- Kraemer A, Mueller RS, Werckenthin C (2012) 455  
Dermatophytes in pet Guinea pigs and rabbits. *Vet*  
456 *Microbiol* 157:208–213 457
- Ledbetter EC, Patten VH, Scarlett JM et al (2007) *In vitro* 458 AU4  
susceptibility patterns of fungi associated with 459  
keratomycosis in horses of the northeastern United 460  
States: 68 cases (1987–2006). *J Am Vet Med Assoc* 461  
231:1086–1091 462
- Mancianti F, Nardoni S, Cecchi S et al (2002) 463  
Dermatophytes isolated from symptomatic dogs and 464  
cats in Tuscany, Italy during a 15-year-period. 465  
*Mycopathologia* 156:13–18 466
- Mantovani A (1978) The role of animals in the epidemi- 467  
ology of the mycoses. *Mycopathologia* 65:61–66 468
- Marchisio VF, Gallo MG, Tullio V et al (1995) 469  
Dermatophytes from cases of skin disease in cats and 470  
dogs in Turin, Italy. *Mycoses* 38:239–244 471
- Mattei AS, Beber MA, Madrid IM (2014) 472  
Dermatophytosis in small animals. *SOJ Microbiol*  
473 *Infect Dis* 2:1–6 474
- Noble JA, Crow SA, Ahearn DG et al (1997) Allergic 475  
fungal sinusitis in the southeastern USA: involvement 476  
of a new agent *Epicoccum nigrum* Ehrenb. ex 477  
Schlecht. 1824. *J Med Vet Mycol* 35:405–409 478
- Pitt JI (2000) A laboratory guide to common *Penicillium* 479  
species, 3rd edn. Food Science Australia CSIRO, 480  
North Ryde 481
- Raper KB, Fennell DI (1965) The genus *Aspergillus*. The 482  
Williams & Wilkins Company, Baltimore 483
- Rebell G, Taplin D (1979) Dermatophytes. Their recogni- 484  
tion and identification. University of Miami Press, 485  
Coral Gables 486
- Rotstein DS, Thomas R, Helmick K et al (1999) Derma- 487  
tophyte infections in free-ranging Florida panthers 488  
(*Felis concolor coryi*). *J Zoo Wildl Med* 30:281–284 489
- Ryoo NH, Ha JS, Jeon DS et al (2009) *Alternaria* perito- 490  
nitis after contact with a cat. *Perit Dial Int* 29:235–236 491
- Sanchez A, Larsen R (2007) Emerging fungal pathogens 492  
in pulmonary disease. *Curr Opin Pulm Med* 493  
13:199–204 494
- Seyedmousavi S, Guillot J, Tolooe-Zarrin A, et al (2015) 495  
Neglected fungal zoonoses: hidden threats to man and 496  
animals. *Clin Microbiol Infect*. doi:10.1016/j.cmi. 497  
2015.02.031. Review 498
- Spiewak R, Szostak W (2000) Zoophilic and geophilic 499  
dermatophytoses among farmers and non-farmers in 500  
Eastern Poland. *Ann Agric Environ Med* 7:125–129 501
- Torres-Rodríguez JM, Dronca MA, Rossell J et al (1992) 502  
Incidence of dermatophytoses in rabbit farms in 503  
Catalonia, Spain, and its repercussion on human 504  
health. *Eur J Epidemiol* 8:326–329 505
- Walsh TJ, Groll A, Hiemenz J (2004) Infections due to 506  
emerging and uncommon medically important fungal 507  
pathogens. *Clin Microbiol Infect* 10:48–66 508

# Author Queries

Chapter No.: 5004      0002617590

Queries	Details Required	Author's response
AU1	Please check the chapter title.	
AU2	Please confirm if contributors of this chapter is okay.	
AU3	The citation Bond et al. (2010a) has been changed to Bond (2010) in here and all other occurrences. Please check.	
AU4	Please check the inserted volume number for Ref. [28].	

Uncorrected Proof