Journal de Mycologie Médicale (2016) **26**, 170—177

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ORIGINAL ARTICLE/ARTICLE ORIGINAL

An epidemiological study of animals dermatomycoses in Iran

Étude épidémiologique des animaux avec une dermatomycose en Iran

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Received 10 October 2015; received in revised form 6 April 2016; accepted 8 April 2016
Available online 11 May 2016

KEYWORDS
Dermatomycosis;
Animal;
Microsporum canis;
Malassezia pachydermatis;
Aspergillus fumigatus;
Dermatophyte

Summary
Objective. — To determine the fungal species isolated from skin lesions of different animals suspected of having dermatomycoses and their prevalence in different regions of Iran.
Materials and methods. — A total of 1011 animals (292 dogs, 229 cats, 168 horses, 100 camels, 98 cows, 60 squirrels, 37 birds, 15 sheep, 6 goats, 5 rabbits and 1 fox) suspected of having dermatomycoses were examined. The samples were obtained by plucking the hairs and feathers with forceps around the affected area and scraping the epidermal scales with a sterile scalpel blade. All collected samples were analyzed by direct microscopy and culture. Laboratory identification of the fungal isolates was based on their colonial, microscopic and biochemical characteristics.
Results. — Fungal agents were recovered from 553 (54.7%) animals suspected of having dermatomycoses. Of 553 confirmed cases, 255 (49.7%) were positive for dermatophytosis, 251 (45.4%) for *Malassezia* dermatitis, 14 (2.5%) for candidiasis, 12 (2.2%) for aspergillosis and 1 (0.2%) for zygomycosis. Cats (36.3%) were the most prevalent infected animals, followed by camels (13.4%), dogs (12.8%), horses (12.5%), cows (12.3%), squirrels (5.4%), birds (3.6%), sheep (2%), goats (1.1%), rabbits (0.4%) and fox (0.2%). *Microsporum canis* (*M. canis*) was the most frequent fungus isolated from dogs and fox, *Malassezia pachydermatis* (*M. pachydermatis*) from cats, horses and squirrels, *Trichophyton verrucosum* (*T. verrucosum*) from cows and camels, *T. mentagrophytes* var. *mentagrophytes* from sheep, goats and rabbits, and *Aspergillus fumigatus* (*A. fumigatus*) from birds.

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http://dx.doi.org/10.1016/j.mycmed.2016.04.007

Conclusion. — The results suggested that periodic screening of animals suspected of having dermatomycoses and necessary treatments could help in the management of their public health problem.

MOTS CLÉS
Dermatomycosis ;
Animal ;
Microsporum canis ;
Malassezia pachydermatis ;
Aspergillus fumigatus ;
Dermatophytes

Résumé
Objectif. — Pour déterminer les espèces fongiques isolées de lésions cutanées de différents animaux soupçonnés d'avoir une dermatomycoses et leur prévalence dans différentes régions d''Iran.
Matériel et méthodes. — Un total de 1011 animaux (292 chiens, 229 chats, 168 chevaux, 100 chameaux, 98 vaches, 60 écureuils, 37 oiseaux, 15 moutons, 6 chèvres, 5 lapins et 1 renard) soupçonnés de dermatomycose ont été examinés. Les échantillons ont été obtenus en arrachant les poils et les plumes à la pince autour de la zone affectée et par grattage des squames épidermiques avec un scalpel stérile. Tous les échantillons prélevés ont été analysés par microscopie directe et par culture. L'identification en laboratoire des isolats fongiques a été basée sur l'aspect des colonies, les caractéristiques microscopiques et biochimiques.
Résultats. — Les agents fongiques ont été récupérés à partir de 553 (54,7 %) animaux soupçonnés d'avoir une dermatomycose. Des 553 cas confirmés, 255 (49,7 %) étaient positifs pour une dermatomycose, 251 (45,4 %) pour une dermatite à *Malassezia*, 14 (2,5 %) pour une candidose, 12 (2,2 %) pour une aspergillose et 1 (0,2 %) pour une zygomycosis. Les chats (36,3 %) étaient les plus nombreux parmi les animaux infectés, suivis par les chameaux (13,4 %), les chiens (12,8 %), les chevaux (12,5 %), les vaches (12,3 %), les écureuils (5,4 %), les oiseaux (3,6 %), les moutons (2 %), la chèvre (1,1 %), les lapins (0,4 %) et le renard (0,2 %). *Microsporum canis* (*M. canis*) était le plus fréquent champignon isolé de chiens et du renard, *Malassezia pachydermatis* (*M. pachydermatis*) chez des chats, les chevaux et les écureuils, *Trichophyton verrucosum* (*T. verrucosum*) provenant de vaches et de chameaux, *T. mentagrophytes* var. *mentagrophytes* provenant de moutons, de chèvres et de lapins, et *Aspergillus fumigatus* (*A. fumigatus*) à partir d'oiseaux.
Conclusion. — Les résultats suggèrent que le dépistage périodique des animaux suspectés d'avoir une dermatomycoses et les traitements adaptés pourraient contribuer à la gestion de ce problème de santé publique.

Introduction

Among many microorganisms in nature, there are over 300 fungi that are actually pathogenic for animals [36]. Fungal infections will appear if the immune system of the host is weak. It is important to determine the factors that contribute to the mycoses development, such as fungi are widespread in nature so eradication is difficult, clinical manifestation is variable (inflammation or allergic reaction), diagnosing is not easy since clinical appearance is different and depends on the host, therapy is difficult since number of available drugs is restricted, and prevention is available for some fungi and only for some animal species [7].

Most of fungi are located superficially and are localized on the surfaces of skin, hair and nails. However, the mechanism between the host and fungus that actually contributes to the disease is not well understood. If the protective barrier is damaged, the skin presents main ''door'' for fungal infection. Dermatomycoses (dermal fungal infections) may occur when fungus contaminates or colonizes epidermis or hair follicles, although it has been reported that clinical changes are not always present [3]. The most significant aspects of dermatomycoses are related to the broadening of knowledge on all the factors that participate in pathogenesis, such as proteases, secretory enzymes, adhesion possibilities and ability to modulate defense mechanisms of the host. In addition, lesions on skin induced by fungus depend on the location and structure of the skin, as well as on the skin product (superficial layer of the skin, hair or nails) [39].

Several fungal agents cause superficial and cutaneous mycoses (most often *Microsporum, Trichophyton* and also *Malassezia* and *Candida* species) [44]. Dermatophytosis is an infectious disease of animals caused by *Microsporum* and *Trichophyton* species that affect the hair shafts, claws and the keratin of the epidermis [12]. These fungi are widespread in nature and its classification depends on the habitat and their presence in various ecology niches. It is a major public and veterinary health problem reported from different parts of the world and causes great economic loss [37]. Yeasts of the genus *Malassezia* inhabit the skin of a variety of mammals and birds where they grow readily owing to the presence of skin surface lipids [41]. However, these yeasts are capable of acting as opportunistic pathogens in animals. They have been implicated in different skin disorders in animals, mainly otitis externa and dermatitis [16]. Several studies on the prevalence and aetiological aspects of superficial mycoses in humans have been conducted in different regions of Iran [2,6]. However, data on the prevalence and other aspects of animals dermatomycoses in Iran are lacking. This study was aimed to determine the fungal

species isolated from different animals suspected of having dermatomycoses and their prevalence in Iran.

Materials and methods

Study population

A total of 1011 animals (292 dogs, 229 cats, 168 horses, 100 camels, 98 cows, 60 squirrels, 37 birds, 15 sheep, 6 goats, 5 rabbits and 1 fox) were examined at the University of Tehran in Iran from March 2003 to February 2013. Animals with skin lesions, such as alopecia and desquamation, were included in this study. The exclusion criteria included the use of antifungal therapy (oral as well as topical) within 2—3 months prior to the commencement of the study. Animals belonged to the warm and humid regions of Iran. In addition, the clinical signs and symptoms, sex and age of examined animals were recorded.

Sample collection

The samples were obtained by plucking the hairs and feathers with forceps around the affected area and scraping the epidermal scales with a sterile scalpel blade following cleaning of affected areas with 70% ethanol. The samples from each lesion were placed in separate sterile Petri dishes and transported to the laboratory within 2 h after collection. The study was approved by the Animal Ethics Committee of the University of Tehran, and informed consent of the animal owners was obtained prior to sample collection.

Direct microscopic and cultural examinations

Each sample collected was divided into two portions. One portion was used for direct microscopic examination using potassium hydroxide (KOH) 20% with dimethyl sulfoxide (DMSO) 10%. The remaining sample was cultured onto Sabouraud dextrose agar (SDA) (Merck Co., Darmstadt, Germany) containing chloramphenicol (0.05 mg/mL), Sabouraud dextrose agar containing chloramphenicol (0.05 mg/mL) and cycloheximide (0.5 mg/mL), and modified Dixon agar (3.6% malt extract, 0.6% peptone, 2% desiccated ox-bile, 1% Tween 40, 0.2% glycerol, 0.2% oleic acid, 1.2% agar, 0.5% chloramphenicol and 0.5% cycloheximide). The plates were incubated at 28 °C and 37 °C for 1—4 weeks and examined at 2—3 day intervals for fungal growth. Fungal colonies on primary isolation media were subcultured onto fresh SDA to avoid contamination and to facilitate accurate identification.

Identification of fungal species

Dermatophyte isolates were identified on the basis of their colony morphology and microscopic examination with lactophenol cotton blue preparation. Pigment production on corn meal agar, urease activity and hair perforation test were also performed [29].

Malassezia isolates were identified by the ability to grow on SDA. The identification of the lipid-dependent yeasts was based on the ability to use certain polyoxyethylene sorbitan esters (Tweens 20, 40, 60 and 80) as described by Gueho et al. [22] and catalase reaction proposed by Guillot et al. [24]. The Cremophor EL assimilation test and the splitting of esculin described by Mayser et al. [34] and precipitate production on modified Dixon agar reported by Hammer and Riley [26] were used as additional tests. Tween test was carried out by a preparation of 2 mL of 10^5 cells/mL yeast suspension that was mixed with 16 mL of Mycosel agar at 40—50 °C. The mixture was homogenized and poured into Petri dishes. After the medium solidified, 4 μL of Tweens 20, 40, 60 and 80 (Sigma Co., St. Louis, MO, USA) was added to each plate at equidistant points and 4 μL of Cremophor EL was placed at the center. All cultures were incubated at 32 °C for 7 days. Presence of catalase was determined on a glass slide; one drop of 10—volume hydrogen peroxide (H_2O_2) was added to a small inoculum of the yeast. The production of bubbles indicated a positive reaction. The identification method described by Guillot et al. [24] permitted figure out some characteristics of the each *Malassezia* specie. *M. pachydermatis* was the only *Malassezia* species that grew in a medium without the addition of lipid; *M. furfur* was the unique species able to assimilate Cremophor El and to use all kinds of Tweens as a lipid source; *M. globosa* strains presented an exclusive globose shape of its cells when visualized by common optical microscopy after Gram staining. Besides this, *M. globosa* was not able to assimilate any kind of Tween as a lipid source. *M. sympodialis* presented a characteristic sympodial budding; it may be differentiated from *M. furfur* by its inability to grow on glucose/peptone agar with 10% Tween 20.

Candida isolates were identified by Cornmeal agar-Tween 80 (Sigma Chemical Co., St Louis, MO, USA) for chlamydospore production of *C. albicans* as well as germ tube test, CHROM agar, β-glucosidase test, urease test, sugar fermentation and assimilation tests by RAPID yeast plus system (*remel Inc., USA*).

For identification of non-dermatophyte fungi, saprophytic colonies were inoculated onto Malt extract agar (Merck Co., Darmstadt, Germany), Czapek-dox agar (Merck Co., Darmstadt, Germany), Potato dextrose agar (Merck Co., Darmstadt, Germany) and Cornmeal agar containing Tween-80 (Sigma Chemical Co., St Louis, MO, USA) for identification at genus level [30]. Laboratory identification of the fungal isolates was based on macroscopic, microscopic and biochemical/physiological characteristics. Macroscopic features included the color of the colonies (both obverse and reverse), the texture of the colonies, whether the colonies were fluffy, powdery, cottony, velvety, etc., whether the hyphae were radiating at the margins and whether the colonies were folded/grooved or furrowed. To examine the isolates for microscopic features, a small portion of the test colony was picked with a sterile needle and placed on a drop of absolute ethanol on a clean microscope slide. The portion of the colony was carefully teased out in the ethanol and the ethanol allowed to evaporate. A drop of lactophenol cotton blue was then added; the slide was covered with a coverslip and viewed under the microscope for the presence, shape, arrangement and relative abundance of micro- and macroconidia.

Statistics

The chi-square (χ^2) test was used to assess statistical differences between the groups. A P value less than 0.05 was statistically considered significant.

Results

Demographic data were presented in Tables 1 and 2. Out of 1011 animals suspected of having dermatomycoses, 553 (54.7%) were positive for fungal agents in direct microscopic and cultural examinations. Of those, 482 cases (87.2%) were diagnosed as microscopic examination-positive dermatomycoses and 553 cases (100%) were diagnosed as culture-positive dermatomycoses (Table 2). Of 553 confirmed cases, 255 (49.7%) were positive for dermatophytosis, 251 (45.4%) for

Table 1 Demographic data of animals suspected of having dermatomycoses.
Données démographiques des animaux soupçonnés de dermatomycose.

Animals	Number of animals	Positive animals (no., %)	Sex (no., %)		Age
			Male	Female	
Dog	292	71 (24.3)	34 (47.9)	37 (52.1)	2 weeks–11 years
Cat	229	201 (87.8)	114 (56.7)	87 (43.3)	1 month–4 years
Horse	168	69 (41.8)	45 (65.2)	24 (34.8)	1 year–20 years
Camel	100	74 (74)	21 (28.4)	53 (71.6)	4 months–4 years
Cow	98	68 (69.4)	13 (19.2)	55 (80.8)	1–8 years
Sheep	15	11 (73.3)	13 (86.7)	2 (13.3)	1–6 years
Goat	6	6 (100)	5 (83.3)	1 (16.7)	1–8 years
Squirrel	60	30 (50)	18 (60)	12 (40)	2 months–4 years
Bird	37	20 (54.1)	12 (32.4)	25 (67.6)	2 months–2.5 years
Rabbit	5	2 (40)	2 (40)	3 (60)	5 months–2 years
Fox	1	1 (100)	1 (100)	–	7 months

Table 2 The results of direct microscopic and cultural examinations and clinical findings of animals with dermatomycoses.
Résultats des examens de culture et microscopiques directs et des constatations cliniques d'animaux avec une dermatomycose.

Disease	Animal	Clinical signs and symptoms	Microscopy positive	Culture positive
Dermatophytosis	Dog	The scaling to inflammatory lesions, hairless and vesicles on the head and trunk	26	36
	Cat	One or more irregular or circular areas of hair loss with or without scales in the body and paws	41	59
	Cow	Circular, painless, thick, white and scattered with occasional production of large plaques in the head, neck and less frequently in the back, flank and limbs	54	68
	Sheep	The scaling lesions on the hairless part of the face, ear and neck	9	11
	Goat	The scaling lesions on the hairless part of the face, ear and neck	6	6
	Horse	Dry, scaly and multiple lesions in any part of the body especially in the groomed part	2	2
	Camel	Extensive hair matting with crusty and hairless lesions mixed with ulcerative nodules and on the trunk	68	74
	Rabbit	Extended alopecia with scaling	2	2
	Squirrel	Hair losses with slight scaling in dorsal site of the body	7	8
	Bird	The scaling and necrotizing lesions in featherless part of the body	6	8
	Fox	Hair losses and inflammation on the tail	1	1
Malassezia infections	Dog	Dermatitis, otitis externa	27	33
	Cat	Dermatitis, otitis externa	138	142
	Horse	Dermatitis	60	67
	Squirrel	Dermatitis	8	9
Candidiasis	Dog	Exfoliative dermatitis in the muzzle, scrotum and feet along with pruritis and alopecia, otitis externa	1	1
	Squirrel	Alopecia, circular skin lesion covered with exudates	13	13
Aspergillosis	Bird	Elevated, yellowish brown, crusted and multifocal lesions located at the base of the feather follicles in the breast	12	12
Zygomycosis	Dog	Necrotic and ulcerative lesions on the head	1	1

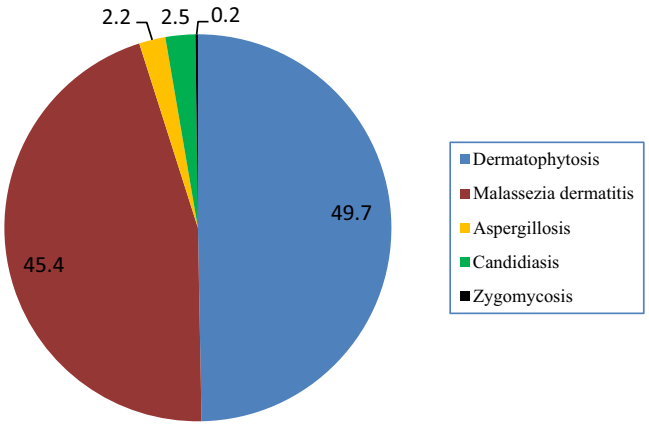

Figure 1 Frequency of different kinds of dermatomycoses confirmed in understudied animals (%).
Fréquence des différentes sortes de dermatomycoses confirmées chez les animaux (%).

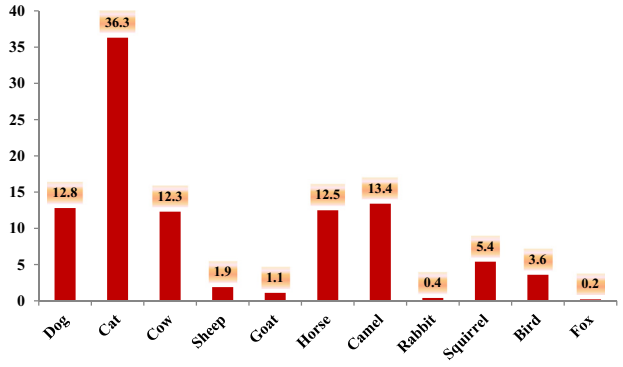

Figure 2 Frequency of fungal species isolated from different animals with dermatomycoses (%).
Fréquence des espèces de champignons isolés des différents animaux avec une dermatomycose (%).

Malassezia dermatitis, 14 (2.5%) for candidiasis, 12 (2.2%) for aspergillosis and 1 (0.2%) for zygomycosis (Fig. 1). Twenty-two fungal species belonging to six genera were isolated from the samples obtained from animals with dermatomycoses including *Trichophyton*, *Microsporum*, *Malassezia*, *Candida*, *Aspergillus* and *Rhizopus*. As shown in Fig. 2, cats (36.3%) were the most predominant affected cases, followed by camels (13.4%), dogs (12.8%), horses (12.5%), cows (12.3%), squirrels (5.4%), birds (3.6%), sheep (2%), goats (1.1%), rabbits (0.4%) and fox (0.2%). *Microsporum canis* (*M. canis*) was the most frequent fungus isolated from dogs and fox, *Malassezia pachydermatis* (*M. pachydermatis*) from cats, horses and squirrels, *Trichophyton verrucosum* (*T. verrucosum*) from cows and camels, *T. mentagrophytes* var. *mentagrophytes* from sheep, goats and rabbits, and *Aspergillus fumigatus* (*A. fumigatus*) from birds (Table 3).

Discussion

Dermatomycoses were characterized by areas of alopecia, crusting and scaling. In this study, dermatophytes were isolated from 49.7% of all the animals examined. The most frequent dermatophyte isolates from different animals were *M. canis* from cats and dogs, *T. verrucosum* from cows and camels, *T. mentagrophytes* var. *mentagrophytes* from sheep, goats and exotic animals, *M. equinum* from horses and *M. gallinae* from birds. In accordance with our results, previous studies exhibited that dermatophytes, such as *M. canis*, *T. mentagrophytes* var. *mentagrophytes*, *T. verrucosum* and *M. equinum*, were the most predominant dermatophyte agents of different animals in many areas of the world [13,28]. Since the incidence of different dermatophyte species varies according to climate and natural reservoirs, the pattern of the species involved in dermatophytosis may be to some extent different in various geographical conditions in animals [40]. In the present study, 24.3% of the suspected dogs were positive for dermatophytosis. The relatively low prevalence of dermatophytes in dogs with suspected lesions of dermatophytosis was well documented in previous studies ranging from 4 to 20% [4,14] and few studies showed higher prevalence [11]. In our study, the most predominant isolated dermatophyte was *M. canis* with frequency of 91.6% in dogs and 94.9% in cats. With few exceptions, *M. canis* was the most common species isolated in the other studies [8], showing a high variability in its percentages of isolation (40—95%). Enzootic situation occurs in catteries with *M. canis*, and eradication of dermatophytosis is particularly difficult in that case due to the presence of numerous animals in a confined environment, or to the dissemination of the dermatophyte through exchanges of cats for reproduction and pet exhibitions. In accordance with our results, *M. canis*, *T. mentagrophytes* var. *mentagrophytes* and *M. gypseum* comprised approximately 96% of the isolated dermatophytes from dogs and cats in the epidemiological studies [43].

The present study showed that *M. equinum* was the causative agent of two horses with dermatophytosis. In a study by Khosravi et al. [28], *M. equinum* was reported as the most predominant isolate in horses with dermatophytosis. Most authors reported that dermatophytosis in horses was mainly caused by *T. equinum*, although other species, such as *M. canis*, *M. equinum*, *M. gypseum*, *T. mentagrophytes* var. *mentagrophytes* and *T. verrucosum*, can usually be found in horse dermatophytosis [10].

T. verrucosum was the most predominant fungal agent of cows with dermatophytosis in this study. According to other findings in Iran, dermatophytosis in cows due to *T. verrucosum* had a high prevalence [28]. Besides *T. verrucosum*, *T. mentagrophytes* var. *mentagrophytes* was sometimes isolated [42], which was in accordance with our results. In this study, the prevalence of dermatophytosis due to *T. mentagrophytes* var. *mentagrophytes* in goats (100%) and sheep (63.6%) was higher than cows (10.3%). The reason of the higher prevalence of *T. mentagrophytes* var. *mentagrophytes* in small ruminants in Iran is not fully understood but it is approved that prevalence of some dermatophytes is changed in different geographical regions because of climate and animal reservoir variations [40].

The present study showed *T. verrucosum* as the only dermatophyte agent in camels with dermatophytosis. Dermatophytosis occurs in camelids-dromedaries and Bactrian camels, as well as in the domestic llamas. *T. verrucosum* was the main responsible dermatophyte although

Table 3 Frequency of different fungal species isolated from animals with dermatomycoses (no., %).
Fréquence de différentes espèces de champignons isolés des animaux avec une dermatomycose (no, %).

Genus	Fungal agents	Dog	Cat	Cow	Sheep	Goat	Horse	Camel	Rabbit	Squirrel	Bird	Fox
Dermatophyte	*M. canis*	33 (91.6)*	56 (94.9)*	0	0	0	0	0	0	2 (25)	0	1 (100)
	M. gypseum	1 (2.8)	1 (1.7)	0	0	0	0	0	1 (50)	2 (25)	0	0
	M. gallinae	0	0	0	0	0	0	0	0	2 (25)	8 (100)	0
	M. persicolor	0	0		0	0	0	0	0	2 (25)	0	0
	T. mentagrophytes var. *mentagrophytes*	2 (5.6)	0	7 (10.3)	7 (63.6)	6 (100)	0	0	1 (50)	0	0	0
	T. verrucosum	0	2 (3.4)	61 (89.7)*	4 (36.4)0	0	0	74 (100)	0	0	0	0
	T. equinum	0	0	0	0	0	2 (100)	0	0	0	0	0
	Total	36 (100)	59 (100)	68 (100)	11 (100)	6 (100)	2 (100)	74 (100)	2 (100)	8 (100)	8 (100)	1 (100)
Malassezia	*M. pachydermatis*	22 (66.7)*	87 (61.3)*	0	0	0	22 (32.8)	0	0	7 (77.8)*	0	0
	M. sympodialis	6 (18.2)	5 (3.5)	0	0	0	8 (11.9)	0	0	0	0	0
	M. furfur	3 (9.1)	4 (2.8)	0	0	0	4 (6.1)	0	0	0	0	0
	M. globosa	1 (3)	14 (9.9)	0	0	0	15 (22.4)	0	0	2 (22.2)	0	0
	M. restricta	1 (3)	2 (1.4)	0	0	0	9 (13.4)	0	0	0	0	0
	M. obtusa	0	21 (14.8)	0	0	0	9 (13.4)	0	0	0	0	0
	M. slooffiae	0	9 (6.3)	0	0	0	0	0	0	0	0	0
	Total	33 (100)	142 (100)	0	0	0	67 (100)	0	0	9 (100)	0	0
Candida	*C. albicans*	1 (100)	0	0	0	0	0	0	0	5 (38.5)	0	0
	C. tropicalis	0	0	0	0	0	0	0	0	5 (38.5)	0	0
	C. glabrata	0	0	0	0	0	0	0	0	2 (15.4)	0	0
	C. kefyr	0	0	0	0	0	0	0	0	1 (7.7)	0	0
	Total	1 (100)	0	0	0	0	0	0	0	13 (100)	0	0
Aspergillus	*A. fumigatus*	0	0	0	0	0	0	0	0	0	9 (75)	0
	A. niger	0	0	0	0	0	0	0	0	0	2 (16.7)	0
	A. terreus	0	0	0	0	0	0	0	0	0	1 (8.3)	0
	Total	0	0	0	0	0	0	0	0	0	12 (100)	0
Rhizopus	*R. oryzae*	1 (100)	0	0	0	0	0	0	0	0	0	0

* Statistically significant ($P < 0.05$).

T. mentagrophytes var. *mentagrophytes*, *M. canis* and *M. gypseum* were sometimes involved [33]. *Trichophyton sarkisovii* was isolated from herds of camels in Kasakhstan and claimed to be specific of camelids [27].

In the present study, *M. gallinae* was isolated from birds with dermatophytosis. In accordance with our results, previous studies indicated *M. gallinae* as the main cause of dermatophytosis in poultry and other fowl [9]. Non-specific lesions of the comb were sometimes associated with other dermatophytes, such as *T. mentagrophytes* var. *mentagrophytes* or *T. terrestre* [21]. Dermatophytosis in poultry is usually rare and it is seen in backyard flocks and those kept under poor husbandry and management conditions.

Our study also exhibited various dermatophytes including *T. mentagrophytes* var. *mentagrophytes* in squirrels and rabbits, *M. gypseum* in squirrels and rabbits, *M. persicolor* in squirrels and *M. canis* in squirrels as well as *M. canis* in fox. Encountered dermatophyte species may differ according to the origin of animals with a preeminence of *T. mentagrophytes* var. *mentagrophytes* in domestic and wild rodents, or in rabbits as well. Interestingly, *M. canis*, which was usually correlated with a domestic environment, was also commonly isolated from wild rodents and leporids, as from soil of borrows, in some surveys. A prey/predator relationship was suspected with foxes, which were also asymptomatic carriers of *M. canis* in the same areas [19].

Malassezia species have been recognized as fungal flora of animal skin; they are also considered to be etiological agents of otitis externa and dermatitis in different animals [15]. In this study, *Malassezia* species were obtained from 45.4% of infected animals. Data available in literature showed the prevalence rates ranging from 19 to 41.2% in animals affected by *Malassezia* dermatitis [16], which were in close accordance with our results. *M. pachydermatis* was detected as the most frequent *Malassezia* isolate in infected cats, dogs, horses and squirrels. Skin of different animals can be colonized by lipid-dependent species in addition to *M. pachydermatis* [23]. The isolation of *M. pachydermatis* together with lipid-dependent species from different animals with *Malassezia* dermatitis was previously reported by several investigators; from cats and dogs by Crespo et al. [16], from cows by Duarte et al. [18], from lions by Coutinho et al. [17], from horses and goats by Crespo et al. [15] and from bats by Gandra et al. [20]. In our study, *M. slooffiae* was isolated from 9 cases of infected cats, which had not been demonstrated in cats in previous reports. In addition, *M. slooffiae* was isolated from the skin of pigs, sheep and goats [22]. In general, the isolation of lipid-dependent species from animals might suggest a potential role of these animals as carriers for humans.

Cutaneous candidiasis caused by *Candida* species is an uncommon disease in animals, whereas it is a common infection in humans [3]. In this study, various *Candida* species including *C. albicans*, *C. tropicalis*, *C. glabrata* and *C. kefyr* were obtained from infected squirrels. To our knowledge, there was no information concerning the dermatomycoses due to *Candida* species in squirrels. Previous studies reported skin infections due to *C. albicans* in dogs [35], guinea pigs [38], rabbits [32], and some other rodents including rats and mice [25], most of which were developed under occlusive dressings and corticosteroid therapies.

Aspergillosis is frequently encountered in the lower respiratory tract of various birds, and occasionally in other organs, such as brain, eye, intestine and skin [45]. The present study showed *A. fumigatus*, *A. niger* and *A. terreus* as the main fungal agents isolated from birds with dermatomycoses. Cutaneous lesions as a manifestation of aspergillosis are rare in avian species. In a study by Yamada et al. [46], *A. fumigatus* was isolated from birds with necrotic granulomatous dermatitis. To the best of our knowledge, the report of Lahaye [31] was the sole study on cutaneous aspergillosis of pigeons. Atkinson and Brojer [5] reported one case cutaneous aspergillosis in a wing of a Great horn owl (*Bubo virginianus*) and Abrams et al. [1] on the head of an hybrid peregrine-gyrfalcon (*Falco peregrinus-Falco rusticolus*).

In conclusion, this work was the first retrospective study on animals dermatomycoses in Iran, providing some baseline information about fungal agents in skin lesions. Dermatophytosis and *Malassezia* dermatitis were the most frequent skin diseases of understudied animals. Routine clinical and mycological evaluations of all animals accompanied with suitable control strategies, i.e. vaccination and improved hygiene, may be useful for managing dermatomycoses as economically important zoonotic infections.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgement

This study was funded by Research Councils of University of Tehran and Amol University of Special Modern Technologies in Iran.

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