The red fox (*Vulpes vulpes*) and Egyptian mongoose (*Herpestes ichneumon*) as carriers of dermatophytes in Portugal

A. C. Matos, S. Saraiva, D. Alves, A. S. Soares, L. Figueira, L. Cardoso, M. Matos and A. C. Coelho

Abstract

Dermatophytosis is a common dermatological infection, affecting humans, pets, domestic ruminants and wild animals. They are a cause for concern as they represent a risk to public and animal health. The aim of this study was to describe the occurrence of dermatophyte infection in wild mammals (road-killed and hunted) in Portugal. Fungal isolation was performed in the fur and scales of 101 wild mammals. Based on the observation of microstructures and colony morphology, fungal isolates were identified to the genus level. Dermatophytes were found in two of the 10 studied species: 3/51 (5.9%; 95% confidence interval [CI]: 0.0–12.3%) red fox (*Vulpes vulpes*), and 5/19 (2.6%; 95% CI: 0.0–9.8%) Egyptian mongoose (*Herpestes ichneumon*). These species represent different taxonomic families: *Canidae* and *Viverridae* and it is therefore important to infer the role of infection in these animals studied for dermatophytosis.

Key words: *dermatophytes; Egyptian mongoose; occurrence; red fox*

Introduction

Dermatological diseases caused by fungi, such as dermatophytosis (commonly termed "ringworm"), are the most prevalent dermatologic infections worldwide (Shimamura et al., 2012; Hube et al., 2015; Paryuni et al., 2020).

Ana Cristina MATOS, MSc, PhD, Research Centre for Natural Resources, Environment and Society, Polytechnic Institute of Castelo Branco, Q-RURAL - Quality of Life in the Rural World, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal; Sofia SARAIVA, MSc, Department of Genetics and Biotechnology, UTAD, Vila Real, Portugal; Daniela ALVES, MSc, Department of Veterinary Sciences, UTAD, Vila Real, Portugal; Ana Sofia SOARES, MSc, PhD, Animal and Veterinary Research Centre (CECAV), UTAD, Vila Real, Portugal; Luís FIGUEIRA, DVM, Research Centre for Natural Resources, Environment and Society, Polytechnic Institute of Castelo Branco, Q-RURAL - Quality of Life in the Rural World, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal; Luís CARDOSO, DVM, MSc, PhD, Department of Veterinary Sciences, School of Agrarian and Veterinary Sciences (ECAV), Animal and Veterinary Research Centre (CECAV), UTAD, Vila Real, Portugal; Manuela MATOS, PhD, Centre for Research and Technology of Agro-Environmental and Biological Sciences (CITAB), UTAD; Ana Cláudia COELHO, DVM, MSc, PhD, Department of Veterinary Sciences, School of Agrarian and Veterinary Sciences (ECAV), (Corresponding author, e-mail: accoelho@utad.pt), Animal and Veterinary Research Centre (CECAV), UTAD, Vila Real, Portugal

In addition to expensive treatment and difficult control, dermatophytosis in animals also poses a risk for public health, due to the high zoonotic potential of the isolated dermatophytes (Chermette et al., 2008; Moriello et al., 2017). Transmission to humans can vary according to geographical location and the type of contact between humans and animals (Gordon et al., 2020).

Microsporum and *Trichophyton* are the most frequently isolated genera in veterinary medicine (Khaled et al., 2014; Gordon et al., 2020). Dermatophytes can be categorised into one of three biotypes: anthropophilic, when causing infection in humans; zoophilic, when causing infection in animals; and geophilic, when present in keratinophilus materials that are dissociated from living organisms and are in the process of decomposition (Akcaglar et al., 2011; Cafarchia et al., 2013; Segal and Frenkel, 2015). Transmission of a zoophilic dermatophyte can occur either by direct contact with the animal, or indirectly through contact with fomites (Lysková et al., 2021).

Unless the infected person is immunosuppressed, infection by dermatophytes is typically cutaneous (Weitzman, 1995), ranging from soft/acute to serious/severe, and occurring in parallel with inflammation, which can sometimes be chronic (Hube et al., 2015).

Microbiological methods are considered the most sensitive methods to diagnose dermatophytosis (Bond, 2010; Moriello et al., 2017). The aim of this study was to describe the prevalence of dermatophyte infection in road-killed and hunted wild mammals in Portugal, including red fox and Egyptian mongoose.

Material and Methods

In this study the presence of dermatophyte fungi in wild mammals was investigated. Animals were found dead as a result of road-traffic accidents or hunting in the cities of Idanha-a-Nova (N 39°55′11″, W 7°14′12″) and Penamacor (N 40°10′8″, W 7°10′14″) in the district of Castelo Branco, centre-eastern Portugal, during the period of 2015–2021. The study received ethical approval from the Ethics Commission of the University of Trás-os-Montes e Alto Douro (Doc31-CE-2015).

A total of 101 wild animals (27 juveniles and 74 adults; 60 males and 41 females) of 10 different species, belonging to seven taxonomic families, were examined: 51 red foxes (*Vulpes vulpes*), five beech martens (*Martes foina*), six Eurasian otters (*Lutra lutra*), three European badgers (*Meles meles*), three common genets (*Genetta genetta*), 19 Egyptian mongooses (*Herpestes ichneumon*), two hedgehogs (*Erinaceus europaeus*), seven wild boar (*Sus scrofa*), four rabbits (*Oryctolagus cuniculus*) and one brown hare (*Lepus europaeus*).

The effects on prevalence of several demographic variables were evaluated. To calculate the sample size, an expected prevalence of 15% with an absolute error of 5% and a 95% confidence level was used.

All wild mammals were clinical examined by a veterinarian, but only two animals presented dermatological clinical signs, such as scales, folliculitis, crusts and alopecic areas with varying degrees of inflammation. Skin lesions were mainly observed on the body.

Collection of data such as location and condition of the cadaver, gender and estimated age of the animal, body condition and other relevant features were recorded in a carefully structured questionnaire. Age was estimated by tooth eruption patterns and tooth wear. During sampling, a clinical examination of all skin surfaces (especially the ears), head and body hairs was performed, in search for signs of ringworm infection, such as erythema, vesicles or pustules,

erosion, scaling and hyperkeratosis. The sampling surface was disinfected with ethanol at 70º C. Samples (fur and skin scrapings) were collected with forceps or scalpel just behind the extending margin in the infected area. Hair strings containing the root end were plucked and sent to Laboratory of Medical Microbiology, Department of Veterinary Sciences, University of Trás-os-Montes e Alto Douro, Portugal.

The samples were inoculated in Dermatophyte Test Medium (DTM, Liofilchem®) and in Potato Dextrose Agar (PDA, Liofilchem®) and incubated for 4 weeks at 25–37°C. The colonies with macroscopic appearance of dermatophyte were cultured again in PDA for isolation and maintenance and then subjected to lactophenol (cotton-blue) staining for microscopic identification. Fungi were identified by their macro- and microscopic morphological characteristics, based on the identification key in the Veterinary Mycology Laboratory Manual (Hungerford et al., 1998) and the Laboratory Handbook of Dermatophytes (Kane et al., 1997).

For the purpose of this study, a wild mammal was classified as infected if a dermatophyte was isolated and identified from at least one culture. Chi-squared ($\chi 2$) tests were used to compare demographic variables and infection. Analyses were performed with SPSS® 25.0 software for Windows considering $P < 0.05$ as statistically significant.

Results

Dermatophytes were isolated from eight of the 101 specimens submitted (7.9%, 95% confidence interval [CI]: 0.69-9.1%). Dermatophytosis positive samples were detected in two suspected animals, and two dermatophyte species were isolated: *Trichophyton mentagrophytes* (4.9%; 95% CI: 0.69-9.1%) and *Microsporum canis* (2.9%; 95% CI: 0–6.3%). Prevalence among males and females was 8.3% (95% CI: 1.3-15.3%) and 7.3% (95% CI: 0.0-15.3%), respectively, and gender-related differences were not statistically significant (P=0.853). Regarding age groups, the prevalence among juveniles and adults was 4.2% (95% CI: 0.0–12.3%) and 9.1% (95% CI: 2.7-15.5%), respectively, and age-related differences were not statistically significant (P=0.435).

Dermatophytes were found in two of the 10 studied mammal species: 3/51 (5.9%; IC 95%: 0.0-12.3%) red foxes (*V. vulpes*), and 5/19 (2.6%; IC 95%: 0.0-9.8%) Egyptian mongooses (*H. ichneumon*). These species represent different taxonomic families: Canidae and Viverridae. Differences were not statistically significant (p = 0.262). Dermatophytes were not detected in any other species or families tested (Table 1).

Microsporum canis was isolated from one red fox and two Egyptian mongoose. *Trichophyton mentagrophytes* was isolated from two red foxes and three Egyptian mongoose. The prevalence of *M. canis* was 1.9% (IC 95%: 0.0-5.76%) in red fox and 10.5% (IC 95%: 0.0-24.32%) in Egyptian mongoose. The prevalence of *T. mentagrophytes* was 3.9% (IC 95%: 0.0-9.25%) in red fox and 15.8% (IC 95%: 0.0-32.19%) in Egyptian mongoose.

Discussion

Through hunting, camping, tourism and agriculture, humans are in contact with wildlife (Mantovani, et al., 1982; Cui et al., 2021). The presence of dermatophytes in wild animals represents a potential infection source to ruminants and humans, and contributes to the further dissemination and persistence of dermatophytosis. This hypothesis was verified in this study, where eight dermatophytes were isolated, representing a prevalence of 7.9%. Dermatophytes were found in two

Table 1. Detection of dermatophytes by taxonomic families and species for wild mammals during the period from 2015 to 2021

Family	Species	Total collected *n*	Total positive *n*	Species prevalence %	95% CI[a]
Canidae (*n*=51)	Red fox (*Vulpes vulpes*)	51	3	5.9	0.0–12.3
Mustelidae (*n*=14)	Beech marten (*Martes foina*)	5	0	—	—
	Eurasian otter (*Lutra lutra*)	6	0	—	—
	European badger (*Meles meles*)	3	0	—	—
Viverridae (*n*=3)	Common genet (*Genetta genetta*)	3	0	—	—
Herpestidae (*n*=19)	Egyptian mongoose (*Herpestes ichneumon*)	19	5	2.6	0.0–9.8
Erinaceidae (*n*=2)	Hedgehog (*Erinaceus europaeus*)	2	0	—	—
Leporidae (*n*=5)	Wild rabbit (*Oryctolagus cuniculus*)	4	0	—	—
	Hare (*Lepus europaeus*)	1	0	—	—
Suidae (*n*=7)	Wild boar (*Sus scrofa*)	7	0	—	—
Total		101	8	7.9	0.7–9.1

[a] Confidence interval

different species, of which only fox (*V. vulpes*) was previously referenced in the literature (Mantovani et al., 1982; Malmasi et al., 2009; Shokri et al., 2016; Gnat et al., 2019). In this study, the species Egyptian mongoose (*H. ichneumon*) was also identified as a dermatophyte carrier and this is, to the best of our knowledge, the first report in these animals. There were no statistically significant differences in the prevalence of dermatophytosis between these two species, or between hosts of different gender or age.

The dermatophytes were identified as *M. canis* and *T. mentagrophytes*. In the literature, there are few epidemiological studies regarding the role of wild mammals in the ecology of dermatophytes. These have already been isolated from wild mammals as wild felines (Bentubo et al., 2006; Albano et al., 2013), alpine marmot (Gallo et al., 2005), wild boar (Mancianti et al., 1997), maned wolf (Pereira et al., 2018), squirrels and camel (Shokri et al., 2016), and hedgehogs (Molina-Lopez et al., 2012; Gnat et al., 2021). A study with larger geographic and taxonomic expansion might reveal that other wild animals are carriers and reservoirs of dermatophytes. As a growing number of wild species are identified as carriers of dermatophytes,

useful tools for the diagnosis of infected animals and measures for the maintenance of territories are necessary to avoid interspecific contact and dissemination. The results suggest that dermatophytes are present in *Canidae* and *Viverridae*, and this study has public health concern in a One Health perspective, since veterinarians and other professional workers, including hunters, who come into contact with these species have a high risk of being infected when handling infected skin and other samples.

This study is the first to show that dermatophytes are present in the fur of Egyptian mongooses, and it provides novel insights into the epidemiology and the role of wild mammals in dermatophyte infection. Further investigations are necessary to clarify the role that red foxes and Egyptian mongooses have in the regional epidemiology of dermatophytes.

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References

1. AKCAGLAR, S., B. ENER, S. C. TOKER, B. EDIZ, S. TUNALI and O. TORE (2011): A comparative study of dermatophyte infections in Bursa, Turkey. Med. Mycol. 49, 602-607. 10.3109/13693786.2010.547879
2. ALBANO, A. P. N., P. DA SILVA NASCENTE, A. T. MEIRELLES LEITE, M. O. XAVIER, R. SANTIN, A. SOUZA MATTEI and M. C. A. MEIRELES (2013): Isolation of dermatophytes in wild felids from screening centers. Braz. J. Microbiol. 44, 171-174. 10.1590/S1517-83822013000100025
3. BENTUBO, H. D. L., D. L. FEDULLO, S. H. R. CORRÊA, R. H. F. TEIXEIRA and S. D. COUTINHO (2006): Isolation of Microsporum gypseum from the haircoat of health wild felids kept in captivity in Brazil. Braz. J. Microbiol. 37, 148-152. 10.1590/S1517-83822006000200010
4. BOND, R. (2010): Superficial veterinary mycoses. Clin. Dermatol. 28, 226-236. 10.1016/j.clindermatol.2009.12.012
5. CAFARCHIA, C., R. IATTA, M. S. LATROFA, Y. GRÄSER, and D. OTRANTO (2013): Molecular epidemiology, phylogeny and evolution of dermatophytes. Infect. Genet. Evol. 20, 336-351. 10.1016/j.meegid.2013.09.005
6. CHERMETTE, R., L. FERREIRO, and J. GUILLOT (2008): Dermatophytoses in Animals. Springer Science+Business Media B.V. (166), 385-405. 10.1007/s11046-008-9102-7
7. CUI, Q., Y. REN and H. XU (2021): The escalating effects of wildlife tourism on human-wildlife conflict. Animals 11, 1378. 10.3390/ani11051378
8. GALLO, M. G., P. LANFRANCHI, G. POGLAYEN, S. CALDEROLA, A. MENZANO, E. FERROGLIO and A. PEANO (2005): Seasonal 4-year investigation into the role of the alpine marmot (Marmota marmota) as a carrier of zoophilic dermatophytes. Med. Mycol. 43, 373-379. 10.1080/13693780400008282
9. GNAT, S., D. ŁAGOWSKI, M. DYLĄG, A. NOWAKIEWICZ (2021): European hedgehogs (Erinaceus europaeus L.) as a reservoir of dermatophytes in Poland. Microb. Ecol. (in press). 10.1007/s00248-021-01866-w
10. GNAT, S., A. NOWAKIEWICZ, D. LAGOWSKI, A. TROSCIANCZYK, P. ZIEBA (2019): Multiple-strain Trichophyton mentagrophytes infection in a silver fox (Vulpes vulpes) from a breeding farm. Med. Mycol. 57, 171-180. 10.1093/mmy/myy011
11. GORDON, E., A. IDLE and L. DETAR (2020): Descriptive epidemiology of companion animal dermatophytosis in a Canadian Pacific Northwest animal shelter system. Can. Vet. J. 61, 763-770.
12. HUBE, B., R. HAY, J. BRASCH, S. VERALDI, and M. SCHALLER (2015): General review dermatomycoses and inflammation : The adaptive balance between growth, damage, and survival. J. Mycol. Med. 5, e44-58. 10.1016/j.mycmed.2014.11.002
13. HUNGERFORD, L. L., C. L. CAMPBELL and A. R. SMITH (1998): Veterinary mycology laboratory manual. Iowa State University Press, Ames, Iowa, USA, 75 pp.
14. KANE, J., R. SUMMERBELL, L. SIGLER, S. KRAJDEN and G. LAND (1997): Laboratory handbook of dermatophytes. Korea, Star Publishing Company.
15. KHALED, J. M., H. A. GOLAH, A. S. KHALEL, N. S. ALHARBI and R. A. MOTHANA (2014): Dermatophyte and non dermatophyte fungi in Riyadh City, Saudi Arabia. Saudi J. Biol. Sci. 22, 604-609. 10.1016/j.sjbs.2014.12.006
16. LYSKOVÁ, P., R. DOBIÁŠ, A. ČMOKOVÁ et al. (2021): An Outbreak of Trichophyton quinckeanum zoonotic infections in the czech republic transmitted from cats and dogs. J. Fungi 7, 684. 10.3390/jof7090684
17. MORIELLO, K. A., K. COYNER, S. PATERSON and B. MIGNON (2017): Diagnosis and treatment of dermatophytosis in dogs and cats: Clinical Consensus Guidelines of the World Association for Veterinary Dermatology. Vet. Dermatol. 28, 266-e68. 10.1111/vde.12440
18. MALMASI, A., A. R. KHOSRAVI, M. SELK GHAFFARI and A. SHOJAEE TABRIZI (2009):

Microsporum canis infection in a red fox (Vulpes vulpes). Iran. J. Vet. Res. 10, 189-191.
19. MANCIANTI, F., W. MIGNONE, R. PAPINI and S. IMPERIA (1997): Keratinophilic fungi from coats of wild boars in Italy. J. Wildl. Dis. 33, 340-342. 10.7589/0090-3558-33.2.340
20. MANTOVANI, A., L. MORGANTI, G. BATTELLI, A. MANTOVANI, G. POGLAYEN, M. TAMPIERI and G. VECCHI (1982): The role of wild animals in the ecology of dermatophytes and related fungi. Folia Parasitol. 29, 279-284.
21. MOLINA-LOPEZ, R. A., C. ADELANTADO, E. L. AROSEMENA, E. OBON, L. DARWICH, and M. A. CALVO (2012): Integument Mycobiota of Wild European Hedgehogs (Erinaceus europaeus) from Catalonia, Spain. ISRN Microbiol. 2012, 659754. 10.5402/2012/659754
22. PARYUNI, A. D., S. INDARJULIANTO and S. WIDYARINI (2020): Dermatophytosis in companion animals: A review. Vet. World 13, 1174-1181. 10.14202/vetworld.2020.1174-1181
23. PEREIRA, K. H. N. P., E. L. R. OLIVEIRA, R. A. B. GONÇALVES, L. S. ROLIM, R. DAS N. D. NETO, M. S. CASTILHO, C. R. TEIXEIRA and S. C. RAHAL (2018): Dermatophytosis caused by Microsporum canis in a free-living maned wolf (Chrysocyon brachyurus). Acta Sci. Vet. 46, 4. 10.22456/1679-9216.86218
24. SEGAL, E. and M. FRENKEL (2015): Dermatophyte infections in environmental contexts. Res. Microbiol. 166, 564-569. 10.1016/j.resmic.2014.12.007
25. SHOKRI, H. and A. R. KHOSRAVI (2016): An epidemiological study of animals dermatomycoses in Iran. J. Mycol. Med. 26, 170-177. 10.1016/j.mycmed.2016.04.007
26. SHIMAMURA, T., N. KUBOTA and K. SHIBUYA (2012): Animal Model of Dermatophytosis. J. Biomed. Biotechnol. 2012. 125384. 10.1155/2012/125384. 10.1155/2012/125384
27. WEITZMAN, I. (1995): The Dermatophytes. Clin. Microbiol. Rev. 8, 240-259. 10.1128/CMR.8.2.240

Crvena lisica (*Vulpes vulpes*) i egipatski mungos (*Herpestes ichneumon*) kao prijenosnici dermatofita u Portugalu

Ana Cristina MATOS, MSc, PhD, Research Centre for Natural Resources, Environment and Society, Polytechnic Institute of Castelo Branco, Q-RURAL - Quality of Life in the Rural World, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal; Sofia SARAIVA, MSc, Department of Genetics and Biotechnology, UTAD, Vila Real, Portugal; Daniela ALVES, MSc, Department of Veterinary Sciences, UTAD, Vila Real, Portugal; Ana Sofia SOARES, MSc, PhD, Animal and Veterinary Research Centre (CECAV), UTAD, Vila Real, Portugal; Luís FIGUEIRA, DVM, Research Centre for Natural Resources, Environment and Society, Polytechnic Institute of Castelo Branco, Q-RURAL - Quality of Life in the Rural World, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal; Luís CARDOSO, DVM, MSc, PhD, Department of Veterinary Sciences, School of Agrarian and Veterinary Sciences (ECAV), Animal and Veterinary Research Centre (CECAV), UTAD, Vila Real, Portugal; Manuela MATOS, PhD, Centre for Research and Technology of Agro-Environmental and Biological Sciences (CITAB), UTAD; Ana Cláudia COELHO, DVM, MSc, PhD, Department of Veterinary Sciences, School of Agrarian and Veterinary Sciences (ECAV), Animal and Veterinary Research Centre (CECAV), UTAD, Vila Real, Portugal

Dermatofitoza je česta dermatološka infekcija koja pogađa ljude, kućne ljubimce, domaće glodavce i divlje životinje. Dermatofiti zadaju brigu i predstavljaju rizik za javno zdravlje i zdravlje životinja. Cilj ove studije bio je opisati pojavnost infekcije dermatofitima u divljih sisavaca u Portugalu, u životinja koje su nastradale u prometu i uhvaćenih divljih sisavaca. Izolacija gljivica obavljena je u krznu i ljuskama 101 divljeg sisavca. Na temelju promatranja mikrostruktura i morfologije kolonije, izolati gljivica su identificirani na razini roda. Dermatofiti su pronađeni u dvije od 10 proučavanih vrsta: 3/51 (5,9 %; 95 % interval pouzdanosti [CI]: 0,0-12,3 %) crvene lisice (*Vulpes vulpes*) i 5/19 (2,6 %; 95 % CI: 0,0-9,8 %) egipatskih mungosa (*Herpestes ichneumon*). Ove vrste predstavljaju različite taksonomske obitelji: *Canidae* i *Viverridae* i stoga je važno donijeti zaključak o ulozi infekcije u ovih životinja ispitanih na dermatofitozu.

Ključne riječi: *dermatofiti, egipatski mungosi, pojavnost, crvene lisice*