Indonesian Journal of Veterinary Sciences
Vol. 2. No. 2 September 2021, Page. 58-67
DOI:10.22146/ijvs.v2i2.85158, ISSN 2722-421X (Online)
Available online at https://jurnal.ugm.ac.id/ijvs

Review

Canine Dermatophytosis in Indonesia, a Tropical Country, Compared to the Non-tropical Countries

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Received: July 11, 2021, Accepted: August 6, 2021, Published: September 1, 2021

Abstract

One of the diseases that commonly affects dogs all around the world is dermatophytosis, a skin disease caused by a group of fungi called dermatophytes. It is understand that dermatophytes can be found in both the tropics and non-tropics. The aim of this review was to explore the prevalence and causative agents of dermatophytosis in canine in different regions. Articles on canine dermatophytosis from Indonesia and a few other non-tropical countries were collected. The data obtained were tabulated and discussed descriptively. The results showed that Indonesia 27/60 (45%) had almost two-fold higher prevalence of canine dermatophytosis compared to the non-tropical countries 287/1,027 (27.95%) considered. *Microsporum canis* was the main causative species found in canine dermatophytosis positive in both the tropics and non-tropics, followed by *Trichophyton* sp. Following that, *Microsporum gypseum* was among the common species found to infect dogs in the non-tropical countries. Other dermatophyte species found in the non-tropics were *Microsporum audouinii* and *Microsporum nanum*. Results obtained from this retrospective study give an illustration on the difference in prevalence and causative agents of canine dermatophytosis in tropical and non-tropical countries.

Keywords: Dermatophytes; dogs; non-tropics; tropics; prevalence

Introduction

Dermatophytosis (ringworm) is a superficial cutaneous fungal infection caused by a group of fungi called dermatophytes that not only invade the cornified layers (stratum corneum) of the skin, but also other keratinized structures like hair and nails of both animals and human (Outerbridge 2006; Quin et al., 2011; Tainwala and Sharma 2011; Weese and Fulford 2011). It is one of the common skin diseases suffered by dogs all around the world and dog patients usually present signs of itchiness in addition to having the classical ring-shaped skin lesions which can be alopecic, erythemic, and can become scaly and crusty (Ganguly and Sharma 2017; Wibisono and Putriningsih 2017). The three main genera of dermatophytes consist of *Microsporum* and *Trichophyton* that affect animals, and *Epidermophyton* that typically affects humans (Mcvey et al., 2013; Paryuni et al., 2020). In general, dermatophytes can be found worldwide but the occurrence of dermatophytosis and the preferred hosts for each dermatophyte species varies according to geographical locations (Moriello et al., 2017; Lagowski et al., 2019). Variations in climate may affect the epidemiology of dermatophytosis too (Maraki and Mavromanolaki 2016).

During rainy seasons, the incidence of canine dermatophytes in India was recorded to

be higher and few studies reported *Microsporum canis* as the predominant dermatophyte species isolated from the dogs while several others isolated *Microsporum gypseum* (Gangil et al., 2012; Singathia et al., 2014; Murmu et al., 2015; Narang et al., 2018; Parmar et al., 2018; Singh et al., 2018). A 16.8% of positive samples from dog specimens were reported by a study in Romania, while the prevalence of dermatophytosis in dogs in Iran was found to be 21.6% with *M. canis* being the predominant species, followed by *Trichophyton mentagrophytes* as well as *M. gypseum* (Yahyaraeyat et al., 2009; Nichita and Marcu 2010). Dermatophytosis cases in dogs in Russia were usually diagnosed in the autumn, with 4.5% incidence (Savinov et al., 2020). A study in Bulgaria suggested that climatic changes had an impact on local cases of canine dermatophytosis as the percentage of positive samples obtained were also higher during autumn in October and November (Michaylov et al., 2004). On the other hand, a higher incidence of *M. gypseum* infections in dogs during summer while *M. canis* in autumn and winter were reported by a study in Italy (Mancianti et al., 2002).

It was observed that the number of people having dogs as companion animals had been increasing over the years (Murray et al., 2005). Therefore, it is important for people to learn more about canine dermatophytosis, starting from the prevalence and causative species, as it is a zoonotic disease (Weese and Fulford 2011). Dermatophytosis in dogs is one of the most common cases detected by veterinarians in Indonesia but the possibility of the causative dermatophyte species being the same or different from other part of the world is still unclear. This study aims to find out the prevalence and the causative agents of canine dermatophytosis in Indonesia, a tropical country that lies on the equator, compared to non-tropical countries such as Iraq (a subtropical country in Western Asia), Turkey (a country that is situated on the border of Western Asia and Southeast Europe), and Ukraine (a country in Eastern Europe), which are all at the north of the equator, by comparing the canine dermatophytosis data obtained from articles collected from those countries that are located at different geographical regions.

Materials and Methods

This was a retrospective study involving main articles from Indonesia, Iraq, Turkey, and Ukraine found through google scholar, pubmed, sciencedirect, and researchgate (Seker and Dogan,2011; Adzima et al., 2013; Indarjulianto et al., 2014; Minnat and Khalaf (2019; Ponomarenko et al., 2019).

The reported data on the prevalence of dermatophytosis in canine and the dermatophyte species prevalent in dogs positive with dermatophytes were sorted out accordingly and tabulated in Microsoft Excel.

Results and Discussion

The prevalence of dermatophytosis in canine in Indonesia 27/60 (45%) was higher than that of Turkey 37/198 (18.69%) and Ukraine 147/664 (22.14%), while lower than that of Iraq 103/165 (62.42%). Overall, the prevalence of dermatophytosis in canine in the tropics 27/60 (45%) was higher than that of the non-tropics 287/1027 (27.95%) (Table 1).

In the tropical Indonesia, 17 (62.96%) of the 27 dogs positive with dermatophytes were

Table 1. Prevalence of dermatophytosis in canine in Indonesia (tropics) and the non-tropics

Country	Authors	No. of samples (dogs showing skin lesion), N	No. of samples positive dermatophytes, n (%)
Tropics			
Indonesia	Adzima et al., (2013)	10	10 (100%)
	Indarjulianto et al., (2014)	50	17 (34%)
	Total	60	27 (45%)
Non-tropics			
Iraq	Minnat and Khalaf (2019)	165	103 (62.42%)
Turkey	Seker and Dogan (2011)	198	37 (18.69%)
Ukraine	Ponomarenko et al., (2019)	664	147 (22.14%)
	Total	1027	287 (27.95%)

infected by *M. canis* while 10 (37.04%) other were infected by *Trichophyton* sp. In the non-tropics, 216 (75.26%) of the 287 dogs positive with dermatophytes were infected by *M. canis*, 50 (17.42%) by *Trichophyton* sp., 12 (4.18%) by *M. gypseum*, 7 (2.44%) by *M. audouinii*, and 2 (0.70%) by *M. nanum* (Table 2). The *Trichophyton* species in Indonesia was not identified but in the non-tropics, the *Trichophyton* sp. were identified as *T. mentagrophytes*, *T. rubrum*, and *T. terrestre* based on the data collected from the articles, where 9.76% of the dogs positive with dermatophytes were infected by *T. mentagrophytes*, 4.18% by *T. rubrum* while 3.48 % were infected by *T. terrestre*.

Tropical countries are countries with tropical climate as they lie across the equator (0°) and within the zone between the Tropic of Cancer and the Tropic of Capricorn which are parallel of latitude at 23° North and South respectively, meaning they get enough sunlight and are warm with an average temperature of above 20°C all year round (Oliver 2005; Morgan 2011). Non-tropical countries are those that lie outside the tropical zone and they can be in the subtropical zone, the temperate zone, or the frigid polar zone. The average temperature in the subtropical usually ranges from 10°C to above 20°C and the one in the temperate zone can be from below 10°C to above 20°C. Both zones have average temperature that varies depending on the seasonal months. The frigid polar zone on the other hand has an average temperature of below 10°C all year round (Oliver 2005).

In general, dermatophytes strive in places with warm and humid environment (Weese and Fulford 2011). However, an anomaly in Table 1 was that the prevalence of canine dermatophytosis in Iraq, one of the non-tropical countries, was shown to be higher than that of Indonesia, a tropical country. This may be due to the reason where most of the sample dogs of the study conducted in Iraq were long-haired dogs and one of the factors that have significant influence on the prevalence of dermatophytosis in dogs is hair coat. While the hair length of dogs were not discussed in the other four articles used as sample source for this study, the study by Minnat and Khalaf (2019) itself reported that dogs with long hair coat had significantly higher percentage of dermatophyte infection than dogs with short hair coat. Animals with long hair coat may be predisposed to dermatophytosis as long hair coat may protect the fungal spores from mechanical removal during licking, thus allowing the spores to remain within the hair more effectively and grow on the underlying skin (Nitta et al., 2016). A study that reported the dog breed, Yorkshire Terrier as the most common breed infected by dermatophytosis, hypothesized that the long hair coat was able to create an optimal micro-environment beneath the coat with ideal temperature and humidity

Table 2. Prevalence of dermatophyte species in canine with dermatophytosis in Indonesia (tropics) and the non-tropics.

Country	Authors	No. of samples positive dermatophytes, n	*M. canis*	*M. audouinii*	*M. gypseum*	*M. nanum*	*Trichophyton* sp.
Tropics							
Indonesia	Adzima et al., (2013)	10	NA	NA	NA	NA	10 (100%)
	Indarjulianto et al., (2014)	17	17 (100%)	NA	NA	NA	NA
	Total	27	17 (62.96%)	NA	NA	NA	10 (37.04%)
Non-tropics							
Iraq	Minnat and Khalaf (2019)	103	73 (70.87%)	7 (6.80%)	3 (2.91 %)	NA	20 (19.42%)
Turkey	Seker and Dogan (2011)	37	17 (45.95%)	NA	4 (10.81%)	2 (5.40%)	14 (37.84%)
Ukraine	Ponomarenko et al., (2019)	147	126 (85.71%)	NA	5 (3.40%)	NA	16 (10.88%)
	Total	287	216 (75.26%)	7 (2.44%)	12 (4.18%)	2 (0.70%)	50 (17.42%)

Note: NA: Data not available.

that allow fungal growth (Brilhante et al., 2003). Therefore, the anomaly where the occurrence of canine dermatophytosis in Iraq was higher than that of Indonesia may be explained by higher number of long-haired dogs was collected as samples for the study of canine dermatophytosis. This situation can be further explained by Minnat and Khalaf (2019) itself where German Shepherd, a breed with long hair coat and also a breed that made up majority of Iraqi police dogs (Tamimi and Wali 2019), made up a larger portion of the sample dogs. Removing this breed from the study will lower the prevalence of canine dermatophytosis in Iraq but still give a higher result if compared to Indonesia. This may be associated with the higher prevalence of ringworm infection in human patients in Iraq compared to Indonesia, where a study in Iraq isolated dermatophytes from 73.64% of the human patients while a study in Indonesia only reported 4.56% of dermatophytosis cases in a total of 417 cases in the medical record data (Hindy and Abiess 2019; Pravitasari et al., 2019), and it was reported that anthropophilic dermatophyte species can infect animals too when there is a contact (Kaplan and Georg 1957; Kano et al., 2010; Ganguly et al., 2017).

Despite the anomaly, overall, Indonesia had almost two-fold higher prevalence of canine dermatophytosis compared to the non-tropical countries. Indonesia has a tropical climate which is warm all year round with an average temperature of 28C and a relative humidity between 70 to 90% (Burton 2006). The results obtained demonstrated that dermatophytosis tends to be more common in warm and humid places like the tropics. For instance, studies on the prevalence of dermatophytosis in canine in other places or countries with tropical climate like Anand in Gujarat, India and Nigeria also showed a higher incidence of dermatophytosis in canine, with a result of 33.33% and 49.5% respectively (Nweze 2011; Parmar et al., 2018).

The predominant species found in canine with dermatophytosis in both the tropics and non-tropics was *M. canis*. *M. canis* is grouped as zoophilic dermatophyte species which prefer animals, especially cats and dogs as the preferred hosts and can be found worldwide (Quinn et al., 2011; Moriello et al., 2017; Lagowski et al., 2019). A study in Mexico isolated *M. canis* from 72.70% of dogs infected by dermatophytes (Torres–Guerrero et al., 2016). Several studies from India detected *M. canis* as the main causative species in dogs positive with dermatophytosis with a percentage as high as 61.1% (Murmu et al., 2015; Debnath et al., 2016; Narang et al., 2018; Singh et al., 2018). One study even reported that *M. canis* was found in all the dogs positive with dermatophyte infection (Parmar et al., 2018). *M. canis* is very common. Despite being a zoophilic species, it has zoonotic potential. *M. canis* was reported to be isolated from human patients with ringworm not only by studies in Indonesia, but also those from Iraq,Turkey, and other countries like Kuwait and Serbia (Akcaglar et al., 2011; Kadhim 2018; Karyadini et al., 2018; Hindy and Abiess 2019; AL-Khikani 2020). In Europe, it was also reported that *M. canis* was the common causative agent for tinea capitis (scalp ringworm), especially in children (Gorgievska-Sukarovska et al., 2017).

Trichophyton sp. made up the second large percentage of species found in canine with dermatophytosis in both the tropics and non-tropics. One study in India reported similar result where *Trichophyton* sp. was the most frequent fungi isolated from dogs with dermatophytosis after *M. canis* (Narang et al., 2018). The *Trichophyton* species in the non-tropics were reported to be *T. mentagrophytes*, *T. rubrum* and *T. terrestre*. *T. mentagrophytes* is one of the most common causative species in canine dermatophytosis. Like *M. canis*, this *Trichophyton* species is grouped in the zoophilic group which prefer animals as the preferred hosts and can be found worldwide (Quinn et al., 2011; Moriello et al., 2017; Lagowski et al., 2019). Therefore, *T. mentagrophytes* may also be the *Trichophyton* species isolated by the studies in Indonesia as this species is among the common dermatophyte species found in dogs (Nweze 2011; Weese and Fulford 2011; Gangil et al., 2012; Singh et al., 2018). On the other hand, *T. rubrum* is grouped as anthropophilic while *T. terrestre* is geophilic (Samanta 2015). These species however have the ability to infect animals under certain conditions or circumstances. *T. rubrum* can be found worldwide and there were studies that reported *T. rubrum* were the species

most commonly isolated from human patients with ringworm (Kadhim 2018; Parmar et al., 2018; Ryan et al., 2020). Dog patients can therefore be infected by *T. rubrum* through a direct or indirect contact with infected humans (Kano et al., 2010; Ganguly et al., 2017). The small percentage of isolated *T. terrestre* suggested that transmission of the geophilic *T. terrestre* occurs only when the dogs come in contact with contaminated soil as stated in some literature (Samanta 2015; Torres–Guerrero et al., 2016).

Following *M. canis* and *Trichophyton* sp., *M. gypseum* was among the common species found to infect dogs in all three non-tropical countries even though the percentage is low. Similar to *T. terrestre*, *M. gypseum* is grouped as geophilic dermatophyte species where the preferred habitat is the soil and can only infect the animals after direct contact (Quinn et al., 2011). A few studies even reported *M. gypseum* as the second most common species isolated from dog patients (Murmu et al., 2015; Debnath et al., 2016; Neves et al., 2018). Other dermatophyte species found in the non-tropics were *M. audouinii* and *M. nanum*. *M. audouinii* was reported as one of the causative species of canine dermatophytosis in Iraq. It is an anthropophilic species that typically affects children of age five to nine-year-old and seldom affects animals (Birchard and Sherding 2006; Sacheli et al., 2020). A case report that isolated *M. audouinii* from a ten-week-old boxer puppy suspected that the infection was transmitted through contact with two of the owner's children that had tinea capitis (scalp ringworm) some time before acquiring the dog (Kaplan and Georg 1957). Therefore, transmission of the *M. audouinii* isolated from canine patients in the study in Iraq was most likely from an infected human. Being both a geophilic and zoophilic species, *M. nanum* preferred hosts are pigs and the occurrence of the infection can be found worldwide (Birchard and Sherding 2006; Quin et al., 2011; Moriello et al., 2017). A small number of *M. nanum* were isolated from dogs with dermatophytosis in the study in Turkey. This was supported by a case study in Brazil that isolated this dermatophyte species from a 7-month-old female Dogo Argentino and the transmission was suspected to be direct contact of the dog with wild boars as this breed of dogs are usually used for wild boar hunting (Valandro et al., 2017).

The total sample size of 60 and 1027 dogs from the studies in both the tropics and non-tropics respectively were enough to provide a valid result of the study as the sample size typically used by researchers intending to use statistical analysis on their data in a study is at least 30 individuals (Cohen et al., 2011). However, some literature suggests a substantially larger number as a greater sample size provides greater power, providing a more precise and reliable estimation (Cameron 2012; Petrie and Watson 2013; Martínez–Abraín 2014). Besides that, if it were possible to have an equal sample size for both categories, the result obtained might give a more accurate representation of the comparison as groups of the same sample size give a greater statistical power. For this retrospective study, the sample articles collected were from different years of publication. There could be a less promising finding when comparing results of canine dermatophytosis studies that were performed in separate years as climate change happens over the years due to global warming, thus each country's climate condition appears to differ every year (BBC, 2020). These changes may affect the growth of dermatophytes as one of the factors that will lead to further changes in dermatophytosis epidemiology is changes in climatic conditions (Maraki and Mavromanolaki 2016). However, the term where the sample articles collected from each country were those that were published in the same year is difficult to satisfy. Therefore, for this study, articles that were published in the past ten years were used as the source of materials to ensure that the data collected were recent enough to provide up-to-date information.

Based on the articles, the samples in Indonesia were obtained from Banda Aceh and Yogyakarta, the one in Iraq were from Baghdad, those in Turkey were from Ankara and Izmir, and the one in Ukraine were from Kharkiv, that is, only one or two out of the many provinces in each countries. Consequently, the results of the studies themselves were not sufficiently complete to represent the countries as a whole, as they represented only about 2 to 6% of the total provinces of the countries mentioned. This is because the distribution of the dog population in each province may be

different. The dog population may vary based on their ownership states, that is, they are either owned dogs or unowned dogs, which in turns will influence their freedom in mobility. Other factors influencing distribution of dog population size across the provinces include human attitude and behaviour affected by religion and culture, reproductive capacity of the dog population, and zoonotic diseases which lead to controlling of the dog populations (International Companion Animal Management Coalition 2008). In Lombok Island, Indonesia, for example, the research on owned and unowned dog population estimation revealed that the trend of dog ownership differs between ethnic groups. In addition, it was recorded that the size of the dog population varies between rural and urban sites, with a greater number of unowned dogs found in urban sites (Mustiana et al., 2015). Zoonotic diseases, particularly those endemic in the province, affect dog population due to the control programs implemented by local and central governments to manage the dog population (International Companion Animal Management Coalition 2008). Those programs or methods used in managing dog population usually include culling, sheltering, and fertility control programs which would affect the population's reproductive capacity (Smith et al., 2019).

The climatic conditions between each province may also be different depending on its topography and this may as well affect the outcome of the studies in the articles themselves because as mentioned before, these changes may affect the growth of dermatophytes. Indonesia is a tropical country with wet and dry seasons, an average temperature of 28°C, a relative humidity of 70 to 90%, and yet, differences exist between the islands and within the island itself. Compared to Yogyakarta in central Java, Banda Aceh in the province of Aceh on the northern end of Sumatra has lower rainfall per year, hence getting lower humidity. Within island, the highlands in western Java have greater rainfall compared to the north-east coast of Java. One example that can be used to describe this is that Bogor has twice as many days of rainfall per year in contrast to Jakarta which is just 60 km up north (Burton 2006). Furthermore, in central Indonesia, the seasonal variations are largely due to monsoons (Lee 2015). This means that, depending on the seasons, the humidity for each province can vary. Yogyakarta in Special Region of Yogyakarta, for example, may have higher humidity compared to Surabaya in eastern Java because it has a higher rainfall count compared to Surabaya in eastern Java (Burton 2006). A study in India reported a prevalence as high as 51.1% of dermatophyte infection in canine during pre-monsoon and/or monsoon months (Singathia et al., 2014). This indicates that the variation in humidity between the provinces in Indonesia due to monsoons or rainy seasons might just play a role in the incidence of canine dermatophytosis. Iraq is a subtropical country where the lowlands and deserts are hot and dry with a long summer and short winter, while the north-eastern has an opposed climate, with longer winters and more rainfall (Rowell 2012). Based on geography, Turkey is located in the Mediterranean with a temperate climate. The complex nature of the landscape with mountains running parallel to the coasts contributes to the considerable differences in climatic conditions between regions. Western Turkey experiences a mild Mediterranean climate with hot, moderately dry summers and cool, wet winters while Eastern Turkey experiences long, cold winter with heavy snow (Sensoy et al., 2016). Ukraine on the other hand, has four agro-climatological zones where it is humid in the northwest, warm in the east and central, semi-arid in the north, and arid in the south (Food and Agriculture Organization of the United Nations 2015). These variations in the climatic conditions between provinces matter and can affect the occurrence of dermatophytosis in canine, demonstrated by a study in Minas Gerais, a state dominated with tropical climate in Brazil, showed that dermatophytes were isolated in 32.5% of the dogs while another study in São Paulo, a state with subtropical climate in Brazil, showed 29.8% (Beraldo et al., 2014; Neves et al., 2018). Therefore, the results of the studies themselves only represented a small part of the countries but not all as the prevalence of canine dermatohytosis and the dermatophyte species that infect the dogs varies according to geographical locations and climatic conditions. The available articles on canine dermatophytosis which can be used as samples are also limited in the respective countries

mentioned. Thus, the findings of this retrospective study only give an idea on how the prevalence and causative species of canine dermatophytosis may differ in the tropics and non-tropics.

Although the articles on canine dermatophytosis available to be used as sample sources are limited and the articles obtained as samples for this study were only confined to certain parts of the countries, the result obtained managed to look at how the prevalence and causative agents of canine dermatophytosis can be different in tropical and non-tropical countries.. Further study that include more sample source from different provinces in respective countries is needed to provide a more accurate and solid comparison.

Conclusion

The incidence of canine dermatophytosis and the causative species for dermatophytosis in canine is different according to geographical locations and climatic conditions. Indonesia had an almost two-fold higher prevalence of canine dermatophytosis compared to the non-tropical countries and the main dermatophyte species found to infect dog patients in both the tropics and non-tropics were *M. canis*, followed by *Trichophyton* sp. Other dermatophyte species that infect dogs in non-tropical countries were *M. gypseum*, *M. audouinii*, and *M. nanum*.

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