

Ringworm Among Cattle

AUTHORS DETAIL

Shakhawan Latif Mahmood¹

¹College of Veterinary Medicine, University of Sulaimani, Sulaimani, Kurdistan Region- Iraq

*Corresponding author:

shakhawan.mahmood@univsul.edu.iq

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INTRODUCTION

Dermatophytosis was first discovered by Gurby during the first half of 19th century. He found *Microsporum audouinii* in human who suffered from tinea capiti (Gräser et al. 2000). Ringworm, dermatophytosis, dermatomycoses or tinea, all refer to the same disease, which is caused by keratinophilic fungi called dermatophytes. A total of six genera may cause ringworm infection, including *Trichophyton*, *Microsporum*, *Epidermophyton*, *Arthroderma*, *Nannizzia* and *Lophophyton*. However, according to formal classification, a total of three genera which is involved in causing the infection. They also attack the superficial keratinized tissues of the nail, claws, skin, and hair of animals and human (Gudding and Lund 1995; Al-Ani et al. 2002; Pal 2007; Dalis et al. 2019; Begum et al. 2020). In addition, *Trichophyton (T.) verrucosum* is an infectious agent of cattle dermatophytosis (Gudding and Lund 1995; Shokri and Khosravi 2016). Besides, *T. mentagrophytes* were also reported among the animals (Shams et al. 2009). This disease is responsible for causing public health problem and large economic losses across the world which include, reduction of milk and meat and production losses besides damage or low grade type of skin structure (Eman-abdeen 2018; Dalis et al. 2018). It is zoonotic pathogen (ElAshmawy and Ali 2016) that is transmitted from animals to humans either via the direct contact with a diseased animal, or indirectly via contact with a contaminated environment. However, contact with arthrospores or conidia are the main rout of transmission of the disease. The high occurrence of ringworm was recorded in winter season. Because, fungal spores grow best in high humidity leading to increase susceptibility of the hosts to ringworm infection (Nooruddin and Singh 1987). However, chances of infection are more in housed animal (Al-Ani et al. 2002; Radostits et al. 2007; Dalis et al. 2014). Infection with dermatophytes is characterized by the development of

ring-shaped lesions which becomes alopecic. Direct microscopic examination, culture, Wood's lamp examination, histopathology, PCR assay are mostly used for diagnosis of the infection (OIE 2013). However, molecular test along with culture results showed as gold standard approaches for detection of the infection (Abd-Elmegeed et al. 2020). In this chapter, we highlighted the etiology, epidemiology, pathogenesis, clinical signs, diagnosis, treatment and control of the infection among cattle.

Etiology and Epidemiology

Conventionally "dermatophytes" are identified in the imperfect fungi or Deuteromycota in three anamorphic genera including: Epidermophyton, Trichophyton, and Microsporum. These are recognized as asexual or imperfect stat. But the teleomorphic state which is "perfect or sexual state " has been described for some species. Dermatophytes are classified in the genus Arthroderma, and phylum Ascomycota (Markey et al. 2013). However, they are regarded as fungi that use keratin for growth. According to many researches about 40 dermatophyte species were recognized so far and only, three genera i.e., *Trichophyton*, *Microsporum* and *Epidermophyton* are identified to be pathogenic for animals and human (Weitzman and Summerbell 1995; Smith 2011; Eman-abdeen 2018). The species of dermatophytes that affected animals are called ectothrix such as the septate hyphae attacking the hair fragment and skin structure into arthrospores and these from a sheath around the infected structures. Besides, these microconidia and macroconidia are created in the laboratory cultures. Macrocoindia of *Trichophyton* spp. is characterized by elongated, cigar-shape with approximately parallel sides. The *Microsporum* spp. tends to yield boat or spindle shaped. Whereas, macrocoindia of *M.nanum* characterized by having pear-shaped and usually two-celled (Markey et al. 2013). According to habitat there are three main types of dermatophytes, called zoophilic (animal), geophilic (soil), and anthrophilic (man). Meanwhile, most bovine dermatophytosis caused by *T. verrucosum* belong to zoophilic (animal), while *T. mentagrophytes* may also causing cattle dermatophytosis along with *Microsporum (M.) canis*. There is difference between dermatophytes species from diagnostic examination and culturing. Furthermore, *T. verrucosum* can remain infective in environment for long periods of almost (5-7) years (Eman-abdeen 2018). *T. verrucosum* can grow at 37 °C, while both *M. canis* and *T. mentagrophytes* cannot grow at this temperature. *T. verrucosum* needs vitamins requirement such as Thiamine and inositol (Eman-abdeen 2018). Socioeconomic status,

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lifestyle, migration, and drug therapy are the main causes of change in the epidemiology of ringworm (Ameen 2010). Dermatophyte-infection have a several range of host species, but it is most frequently reported in those areas where animals are housed in dense groups, particularly indoors (Radostits et al. 2007). The route of transmission of the infection is through contact with infected inanimate objects or direct contact. Furthermore, carrier animals are the source of infection (Radostits et al. 2007). Fungal diseases will emerge if the immune system of the host is weak (Shokri and Khosravi 2016). In addition, the occurrence and distribution of ringworm is also influenced by host factors (stress, age, management and transportation), climate condition and geographic area (Al-Rubiay and Al-Rubiay 2006). However, the factors such as species, numbers and age of animal besides environmental aspects will serve a significant role in the rate of infection (Eman-abdeen 2018). Furthermore, a study conducted by Marai et al. (1999) showed that the rate of ringworm infection among cattle was higher in foreign breed than in native breed. According to studies conducted by Pascoe (1979) and Shams et al. (2009) the prevalence rate was higher in the young animals. Another study by Abd-Elmegeed et al. (2020) showed higher infection rates in male animals as compared to female animals (Abd-Elmegeed et al. 2020). Many studies reported cattle infection with *T. verrucosum* in the Asian countries, including Iraq (Hussein et al. 1989; AL-Samarrae 2009), Iran (Shams et al. 2009; Shokri and Khosravi 2016), Turkey (Ozkanlar and Kirecci 2009), Saudi Arabia (Khaled et al. 2015) and Egypt (Abou-Gabal et al. 1976; Bagy et al. 1986; Abd-Elmegeed et al. 2020). The prevalence of fungal infection were also found significant in European countries, including United Kingdom (Oldenkamp 1979), Norway (Stenwig 1985), Germany (Berlin et al. 2020), and Italy (Atzori et al. 2012). Season plays a role in the intensity of the disease transmission, for example (Al-Ani et al. 2002; Radostits et al. 2007, Dalis et al. 2014; Abd-Elmegeed et al. 2020) showed that the incidence rate of the disease was peaked in winter. Table 1 shows the prevalence rate of bovine ringworm infection in various countries.

Pathogenesis

Dermatophytes invade in the keratinized tissues, chiefly the hair fibers and stratum corneum, and causing the hydrolysis of the fiber structure, and breaking off of the hair, which ultimately leads to alopecia (Radostits et al. 2007). The body of animal host shows hypersensitivity reaction against the metabolic products of the pathogen leading to development of lesion. However, the host mounts an inflammatory response that is harmful to the fungus, so the dermatophyte moves away peripherally towards normal skin. It ultimately leads to the development of circular lesions with alopecia having healing at the center and inflammation at the edge. (Markey et al. 2013). The importance of epidermis pH in the growth of dermatophytosis is usually known (Radostits et al. 2007).

Clinical Signs

Among cattle, ringworm infection ranges from small focal lesions to extensive pathogenesis involving the entire body (OIE 2013). Characteristically, the lesion is a heavy, grey-white crust that is elevated perceptibly above the skin. The lesions are circular, almost 3 cm in diameter and are commonly found on the neck and head, particularly around the eyes and face. However in severe diseased animals, it may be observed over the whole body (Apaydin and Atalay 2007). In addition, the clinical signs usually resolve spontaneously during 2 to 4 months (OIE 2013). However, according to Guo et al. (2020) the skin lesion was reported in different body sites. The highest rate was 38.71% in head, and lowest rate was 9.68% in whole body (Fig. 1).

Diagnosis

The diagnosis of bovine dermatophytosis is generally based on history, close physical examination, clinical signs, direct microscopic examination, Wood's lamp examination and histology of the tissues (Apaydin and Atalay 2007; Swa and Sanka 2012) However, molecular diagnostic test along with culture results showed as gold standard approaches for detection of the infection (Abd-Elmegeed et al. 2020). Traditional method for detection of the infection in dermatophytes suspected lesions by using 20% KOH (Ellis et al. 2007). Dermatophyte organisms can be cultured on several fungal media, including dermatophyte test medium (DTM) and Sabouraud agar (SDA) (with cycloheximide and antibiotics). These are usually incubated at room temperature (20–28°C). While, *T. verrucosum* needs higher temperatures. However, colonies often become visible within 7-14 days (OIE 2013). Fungal cultures, is important to recognize the source of dermatophytosis and targeting preventive measures appropriately. Culture may also be needed in either the diagnosis is uncertain, or the infection is resistant to standard therapy (OIE 2013). *T. verrucosum* is usually characterized by very slow growing white, cottony, non-pigmented reversed side colonies having heaped up, and button like appearance with folded areas (Dalis et al. 2014; Eman-abdeen 2018). In contrast to microscopical picture, *T. verrucosum*-agent appear as septated hyphae and microconidia with existence of *chlamydo spores* which arranged in chain (Eman-abdeen 2018). However, molecular diagnostic test along with culture results showed as gold standard approaches for detection of the infection (Abd-Elmegeed et al. 2020). Molecular tests such as PCR have been efficiently used for investigation of the organisms which proved to be more specific, accurate and stable than phenotypic characterization(Graser et al. 2000).

Treatment and Control

Ringworm causes a self-limiting infection showing natural recovery in mild cases. While, different antifungal such as topical iodine and Sulphur preparation are applied for

Table 1: shows the main differentiation between the two genera including *Trichophyton* spp and *Microsporum* spp. by microscopic examination.





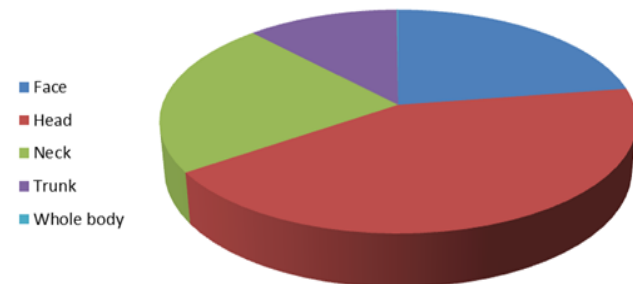
	<i>Trichophyton</i> spp.		<i>Microsporum</i> spp.	
				
	Macroconidium	Microconidia	Macroconidium	Microconidia
Macroconidia	Relatively insufficient or lacking among various species. If existing they are elongated and pencil or cigar-shaped. Their walls are smooth and thin; where distributed by septa into 3-8 cells		Large thick-walled and separated into numerous cells by transverse septa. They are boat or spindle-shaped.	
Microconidia	Generally, these are several in number and borne singly along the hyphae or in grape-like clusters.		Moderately insufficient or lacking. If existing these are tear-shaped and borne singly on the hyphae.	

Table 2: Bovine ringworm's prevalence rate in different countries

Locations	Prevalence rate	References
Central region of Iraq	21.2 %	(Hussein et al. 1989)
Ninevah, Mosul, Iraq	26.5%	(Arslan et al. 1998)
Baghdad, Iraq	68 %	(AL-Samarrae 2009)
Diyala, Iraq	90 %	(Jameel 2015)
Ningxia, China	15.35 %	(Guo et al. 2020)
Different parts of Jordan	30.6 %	(Al-Ani et al. 2002)
West Bank of Jordan	59.3 %	(Ali-Shtayeh et al. 1988)
Ankara, Turkey	33.33 %	(Sever et al. 2017)
Barcelona, Spain	25 %	(Cabanes et al. 1997)
Nweze, Nigeria	12.6 %	(Nweze 2011)
Thamar, Yemen	11 %	(Golah et al. 2012)
Brazil	58.3 %	(Duarte et al. 2013)

treatment of severely affected lesions. Some researchers also recommended the removal of scales and crust before applying the ointment preparation. In addition, there are systemic antifungal treatments but may left some residues which has harmful or toxic effect on animals or human body (Araújo et al. 2009). Furthermore, plant fungicides like chlorhexidine and captan, iodide shampoos and tinctures, 5 per cent lime sulphur, enilconazole, thiabendazole, sodium tolnaftate, and fluorides (toothpaste) are also used for topical treatment. Sodium iodide and *T. verrucosum* vaccine may also be used to treat the infection by intravenous and intramuscular injection, respectively. In addition, griseofulvin used orally to treat the infection (Pandey 1979; Apaydin and Atalay 2007). On the other hand, ivermectin significantly can be used to treat the disease (Jameel 2015). In recent studies, natural antifungal plants have been developed, because these are effective, have low cost, easily applied under field conditions and less toxic. Lemon grass, garlic, ginger, acacia, datura, a triplex, neem, black seed,

**Fig. 1:** Distribution of Ringworm in different body regions

eucalyptus, basil and alfalfa are some types of natural plant. Recent study by Eman-Abdeen and El-Diasty (2015) showed that Clove oil proved highly effective antifungal activity against the infection invitro and can be used as a topical spray and ointment for treatment of ringworm. Failure to control an outbreak of dermatophytosis is frequently due to the widespread contamination of the environment before treatment is attempted. In addition isolation, treatment of infected animals, cleaning and disinfection of stables are need (Radostits et al. 2007). Vaccination has an important role to prevent the infection among cattle and horses (Radostits et al. 2007). Both innate and adaptive immune mechanisms are involved in the response to the infection. Moreover, it has been found that antigens of *M. canis* and numerous species in the genus of *Trichophyton* stimulate both humoral and cell-mediated immune responses (Pier et al. 1992; DeBoer and Moriello 1993). Among cattle, *T. verrucosum*-agent is the main cause of the infection; rarely *T. equinum*, *T. mentagrophytes* and *M. canis* are isolated from lesions of the infected animals (Stenwig 1985; Radostits et al. 2007). The goal for the

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prevention of cattle dermatophytosis is to obtain an effective vaccine against *T. verrucosum* infection. Both live attenuated and inactivated vaccine" for the agent have been developed. In most of Europe, there are currently four available dermatophyte vaccines (Lund and DeBoer 2008). However, the main common method for assessment of vaccine safety and efficacy and characterization of the immune response involves the target animal species. A few studies have used heterologous challenge strains indicating some degree of cross reactions (Lund and DeBoer 2008). In Norway, there is a program to eradicate bovine dermatophytosis in herds by vaccination, isolation of infected animals, good hygiene and disinfection of contaminated stables. In one region of Norway, over a period of 8 years, where 95% of flocks participated, the infection rate of the disease reduced from 70% to 0% (OIE 2013).

Conclusions

The disease is commonly known by several names including ringworm, dermatophytosis, dermatomycoses or tinea. *T. verrucosum* is the main cause of bovine dermatophytosis. The main route for spread of infection from animals to humans is through direct contact. Molecular assay along with culturing serve as a gold standard approaches for diagnosis. The high incidence of the infection is usually recorded in winter season. The occurrence and distribution of ringworm is influenced by host factors (stress, age, management and transportation), climate condition and geographic area. Vaccination has an important role to prevent the infection among cattle and horses. Natural antifungal plants i.e., clove oil proved highly effective against the infection and can be used as a topical spray and ointment for treatment of ringworm.

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