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Fungal skin lesions of Camelids: Review article

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Abstract

The Arabian camel (Camelus dromedarius) is a desert animal. Like other animals, camel is infected with fewer infectious diseases; however, skin diseases are still considered a crucial problem. There are various causative agents of Camelidae skin diseases, including nutritional and mineral deficiency, viral, parasitic, bacterial and fungal diseases. A review of the literature revealed scarce publication on Camelidae skin diseases. This review of literature intends to focus on important fungal skin diseases that affect *Camelus dromedarius* from various aspects like Dermatophytosis, Skin Candidiasis and miscellaneous fungal infection.

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Introduction

Globally, the number of fungal and fungal-like diseases of animals and plants in both natural and controlled systems has increased, as a result of environmental alterations, over the last two decades (Fisher et al., 2012). Camelids are like other mammals, may be affected by several fungal diseases, however, only some are well described. These diseases are dermatophytosis (ringworm) (Al-Salihi et al., 2013; Abou-Zaid, 1995; Mahmoud,1993; Al-Ani et al., 1995; Gitao et al., 1998), Aspergillosis spp (Bhatia et al., 1983; Pickett et al., 1985, Severo et al., 1989; El-Khouly et al., 1992; Gareis and Wemery. 1994) , Candidiasis (moniliasis) (Lamm et al., 2009; Hajsig et al., 1985; Wernery et al., 2000), Coccidioidomycosis and Mucormycosis (Muir, 1982; Fowler et al., 1992; Fowler, 1998) ,Cryptococcosis (Griner, 1983), Histoplasmosis (Chandel, 1994), Phycomycosis (Satir et al., 1993) and Zygomycosis (Moll et al., 1992). This review of literature proposes to emphasis on the important camelids fungal skin diseases from various aspects like Dermatophytosis, Skin Candidiasis and miscellaneous fungal infection.

Dermatophytosis

Camelids dromedaries, Bactrian camels, domestic llamas, and wild ruminants are affected by ringworm. Mycotic dermatitis is among diseases of camelids caused by fungi. *Trichophyton verrucosum* is the main responsible dermatophyte although *T. mentagrophytes*, *Micosporium canis* or *M. gypseum* are sometimes involved (El-Timawy *et al.,* 1988; Mahmoud, 1993; Fadlelmula *et al.,* 1998; Thedford *et al.,* 1989). Dermatophytosis and candidiasis are of particular concern, due their worldwide diffusion and, for some of them, zoonotic potential. In all cases, early diagnosis is essential in order to accomplish an encouraging prognosis. Understanding of the epidemiology, clinical signs, and diagnosis of fungal diseases is important for the launch of effective therapeutic strategies. There are few published articles regarding mycotic dermatitis of camelids. Ringworm, or dermatophytosis, is a highly contagious infection of the keratinized tissue of domestic animals and man. It is one of the three common diseases caused by genera of fungi collectively called *dermatophytes*. There are few published records documenting dermatomycosis of the camel (Connole, 1975). However, Falah, 2004, defined the dermatophytosis in camelids as a group of closely related fungi that utilize keratin for growth and its classical lesion are circular and known as "ringworm (Al-Ani, 2004). Previously, there are poor understanding about the susceptibility of camels to dermatophytosis. There is a misconception that camels are not infected by dermatophytes, as their keratin differs from the keratin of other animals. However, Kuttin *et al.,* (1986) approved the contrary. Their survey on ringworm in camels, showed over 25% of young animals suffered from *T. verrucosum* infection, and less than 0.5% of the camels had *T. mentagrophytes*. They also found that analyses of the amino acid of hair samples taken from human, camel and cow, showed 11% similarity in the compositions.

Based on the location of the infection, fungal diseases are classified into:

- Superficial mycoses, caused by pathogens confined to the stratum corneum except hairs.
- Cutaneous mycoses, caused by pathogens invading keratinized tissues (including hairs, horns and skin).
- Subcutaneous mycoses.
- Deep mycoses which affect the upper and/or lower respiratory tracts, as well as internal organs (De Hoog *et al.,* 2009).

Causes of Dermatophytosis

Approximately 30 species cause skin infections in various mammals and birds and relatively few species are routinely isolated. There are significant differences in the species of a relative importance among different animal hosts. There are also important geographic differences in the dermatophytes encountered and the prevalence of the disease. Dermatophytes, a group of keratinophilic fungi thriving on the keratin substrate, are the etiological agents responsible for causing cutaneous infections. These organisms belong to the three genera namely *Trichophyton*, *Microsporum* and *Epidermophyton* (Emmons et al., 1977). Infection may also be

caused rarely by the members of the genus *Candida* and non-dermatophytic moulds belonging to the genera *Fusarium*, *Scopulariopsis* and *Aspergillus* (Pinto et al.,2006; Naveed *et al.,* 2009). Several pathogenic dermatophytes (ringworm) infections have been described in OWC and NWC but they are scarce. Several dermatophytes spp have been isolated from camelid's skin lesions worldwide. The most common dermatophytes isolated from camelids are *Trichophyton verrucosum* (Abou-Zaid, 1995; El-Timawy *et al.,* 1988; Mahmoud, 1993; Fadlelmula *et al.,* 1994; Naveed *et al.,* 2009; Currasson,1947; Nasser, 1969; Torky and Hammad, 1981; Khamiev, 1981; Khamiev, 1982; Khamiev, 1983; El-Kader, 1985; Tuteja et al., 2013), *Trichophyton mentagrophytes* (Refai and Miligy,1968; Tuteja et al., 2013), *Trichophyton schoenleinii* (Tuteja *et al.,* 2013; Kamel et al., 1977; Chattejee et al., 1978), *Trichophvton sarkisovii* was isolated from herds of camels in Kasakhstan and was claimed to be specific of camelids, but this species is now synonymised with *T. mentagrophytes* (Ivanova and Polyakov, 1983; Rene´, Chermette *et al.,* 2008; Ivanova, 1987), *T. equinum , T. concentricum, T.tonsurans, T.violaceum, T. soudanense and T. rubrum were also reported in India* (Tuteja *et al.,* 2013). *Microsporum gypseum* (Kamel et al., 1977; Boever et al., 1975; Fischman et al., 1987; Mancianti et al., 1988), *Microsporum canis* (El-Timawy et al., 1988; El-Kader, 1985; Tuteja et al., 2013). *M. audouinii*, *M. canis, M. nanum, M. ferrugineum* (Tuteja et al., 2013), Human pathogenic fungi (*Epidermatophyton floccosum* and *Scopulariopsis brevicaulis*) were also isolated from camels in India (Tuteja *et al.,* 2013). The other fungi rather than dermatophytes are also isolated. These fungi are *Sporothrix schenckii* (Currasson, 1947) *; Candida albicans* (Wernery et al., 2000)*; Penicillium vinaceum, Pseudorotium, spp., Pseudoarachniotus spp., Allescheria spp., Mycelia sterile* (Singh and Singh, 1969) *, Cryptococcus neoformans* (Ramadan, 1989), *Chrysosporium* (Mahmoud , 1993). Some fungal flora genera are also isolated from camel healthy skin. These flora are *Aspergillus, Penicillium, Mucor, Alternaria alternate, Rhizopus, Chrysosporium, Acremonium , Scoupolariopsis , Cladosporium, Fusarium, Psuedallescheria boydii* and *stachybotrys atra* (Wernery and Kaaden, 2002). The frequently isolated Yeasts are *Candida,Geotrichum candidum and Malassezia* (Khosravi et al., 2007).

Geographic distribution

The researcher reported ringworm of camels in different geographical areas around the world. Ainsworth and Austwick, 1959 (Ainsworth & Austwick, 1973), reviewed critically dermatophytosis in animals. They stated that ringworm in the camel is briefly reviewed by Curasson, (1947, p.371). They also mentioned, “This condition is not well understood and the status of *Trichophyton langeroni* (Grubyella langeroni Baudet) and Aleurisma lugdunense VUil” (from dromedaries “from Algeria in the Hague zoological gardens”) and *T. dankaliense* (from a piece of camel skin) is uncertain (Kuttin& Beemer, 1975.; Baudet, 1930; Baudet, 1930). A few reported cases of camel ringworm led to consider the disease as a rare conditions (Ghoke et al., 2006) . Later on, several dermatophytes cases have been reported in different area in the world. *T. dankaliense* has been reported in Northern Somalia and the Ogaden area, it was affected camels and humans. However, *T. mentagrophytes*, *T. verrucosum* and *Microsporum gypseum* were isolated from

camel ringworm in Australia and Israel (Ainsworth & Austwick, 1973; Connole, , 1975; Kuttin & Beemer, 1975)

In India ringworm due to *T. schoenleinii* was recorded [42], (Chaktaborty et al 1978). In 2006, Ghoke et al., (2006) , studied the prevalence of dermatophytosis in Indian dromedary (Camelus dromedarius) belonging to an organized farm located in Kutch area of Gujarat. *Trichophyton verrucosum* was only isolated from 2 camels with cutaneous lesions between totally 18 camels of both sexes. The different age groups were showing skin lesions on several body sites. However, no epidemiological investigation was conducted to establish the source of infection and they were suggested that *T. verrucosum* infection should be considered in the differential diagnosis of dermatitis. In 2013, Tuteja et al, was isolated *Epidermatophyton floccosum* and *Scopulariopsis brevicaulis* as a causative agents of skin infections in two camel herds (Tuteja et al 2013). Sporadic cases of skin infection in individually maintained camels caused by species of common dermatophytes were also reported in India in 2013.

In Egypt, Mahmoud (1993), diagnosed the fungal infection between camels. The percentage of positive skin lesions with fungal infection were 48%. In addition, the younger individuals were more susceptible to this infection. *Trichophyton, Microsporum* and *Chrysosporium* were the most common genera. *T. verrucosum* appeared to be the main cause of ringworm in small camels while *T. mentagrophytes* infected older ones. El-Timawy *et al*., 1988 [22], reported also *T. verrucosum, T. mentagrophytes*, *Microsporum canis* and *Microsporum gypseum* in camels. In 2006, Amin *et al*., [57] examined a total of 47 skin scrapings from 27 local and 20 imported dromedary camels that showed skin lesions during summer and winter seasons. They found that ringworm infection rate was 14.81 and 12.5% in local camels in summer and winter, respectively, however, no cases of ringworm were observed in imported camels.

In Saudia Arabia, mycotic dermatitis due *Cryptococcus neoformans* is reported in camels[50]. In addition, dermatophytosis due to *Microsporum gypseum* mixed with *Dermatophilus congolensis* in camels (Camelus dromedarius) was also reported (Gitao et al., 1998).

In Iraq, dermatomycosis caused by *T. schoenleinii* was reported (Al-Ani et al., 1995). Whereas, Hussain, (2009), isolated *Tricophyton verrucosum, Microsporum canis,* and four non dermatophytes *"Penicillium brevicompactum, Ulocladium chartarum, Aspergillus fumigates*, and *Scopulariopsis bainier* from skin affections of camels in three different Iraqi Governorates. Two type of dermatophytes were isolated from 10 cases from 40 camels showed "dry scaly lesion " in one survey study between 2012-2013 in Al-Najaf slaughter house. The isolated fungus were *T. verrucosum* 60% and *T. tonsurans* 40% and non dermatophytes (*Penicillium spp*., *Aspergillus niger*, *Aspergillus ochraceous*, *Geotricum spp*) Al-Ani, 2012). Mixed dermatomycosis and mange infection in camels accompanied with chronic granulomatous hidradinitis was also reported in camels in Iraq by Al-Salihi *et al.,* (2013).

In Iran, 11 (77%) *Trichophyton verrucosum* and 3 (21%)*Trichophyton mentagrophytes* isolates was isolated from camel (Hussain et al., 2012). A mixed infection of *Trichophyton verrucosum* and *Nocardia asteroides* was also reported (Khosravi et al., 2007). Whereas, Ebrahimi, *et al.,* (2007), also reported the

incidence of dermatophytes in 143 hair coat / skin scraping sample of healthy camels from Najafabad slaughter house.
In Sudan Dermatophytosis also reported in Eastern Sudan (Fadlelmula et al., 1994). Mycotic dermatitis was also reported in camel in Alshowak, in Eastern Sudan and in Alobied in North Kordofan, Sudan (Wisal et al., 2010). In Oman, dermatomycosis is also reported in camels by Kumar *et al.,* 2012 (Kumar et al., 2012). They found ringworm the most frequent occurring conditions (95%) encountered throughout the year.
In Morocco, Driot *et al .,* (2011) has been studied the epidemiology and histopathology of ringworm at the slaughterhouses in the southern Moroccan towns. The mean prevalence of the disease was 16% among all animals, 44% among animals with skin lesions. Most of the concerned camels were young.

Economic importance

Dermatophytes consider as a major public and veterinary health problem reported from different parts of the world. It causes a great economic loss in the camels industry. It has mainly severe effects on Leather Industry from the camel. It effects the quality of the hide due to the ability of dermatophytes organisms to break down the keratin in tissues such as the epidermis, hair, nails, feathers, horns and hooves (Calderone, 1989; Abu Samra, 1979). The hide of the dromedary in camel producer countries is mainly used for making whips and saddles (Abu Samra, 1979) and to make a gourd-like container for water and milk [65]. Many countries have commercial tanning of camel leather such as Egypt, which is pioneered in this industry. Camel's leather is very versatile and has two unique properties. These are its exceptional tensile strength and an attractive grain pattern on the tanned product. These features ensure its demand for the manufacture of a wide range of products such as; shoes and boot uppers, hats, fashion accessories, briefcases, garments, harness and sporting goods. The disease has also zoonotic potential impact. In living hosts, dermatophytes usually remain in superficial tissues such as the epidermis, hair and nails. Serious consequences are uncommon and infections can be self-limiting. However, the illness may be disfiguring and uncomfortable, especially when the lesions are widespread. Infrequently, dermatophytes may invade subcutaneous tissues and (very rarely) other sites, especially in immunocompromised hosts.

Susceptibility

In general, younger animals are most susceptible for dermatophytosis (Sparkes *et al.,* 1993; Pascoe, 1979). Animal less than one year of age are at greater risk for dermatomycosis and may reflect a lack of specific immunity acquired after first exposure, but also innate immune mechanisms, such as the quantity and nature of sebaceous lipids in the epidermis (Hay *et al.,* 1992). Older animals with decreased immune function also may be at increased risk for generalized dermatomycosis (Fadlelmula et al., 1994; Wisal et al., 2010; Scott, 1988; Gupta and Singh, 1969; McPherson, 1957). Dermatophytosis is a common skin disease in OWC under 3 years of age with a peak incidence age of 3 to 12 months. In NWC it is, however, very rare disease17 and only T. verrucosum and T. mentagrophytes have been

isolated from NWC so far. The skin lesions caused by T. verrucosum in the camels were very similar to those found in cattle. In both animal species, cows and camels, the younger individuals are more susceptible to the fungus. The infected suckling offspring did not infect lactating camels. There is no significant difference in the susceptibility of male and female camels to ringworm infection (Fadlelmula et al., 1994; Wisal et al., 2010). However, contrast were recorded with a higher prevalence of ringworm infection in she camel (77%) than the males (23%) (Khamiev, 1982; Khamiev, 1983).

Transmission of the disease and predisposing factors

Direct and indirect contact with infected animals (or asymptomatic carriers/or from the environment) and fomites are the modes of transmission of dermatophytes. However, the whole epidemiological features of ringworm in camelids, are yet unexplored. Outbreaks of dermatophytosis can persist due to the contamination of reservoir and fomites, such as tack and grooming equipment, and loans of equipment may spread infection between barns. Asymptomatic carrier camels are especially risky for the spread of infection to humans, because no precautions are taken to prevent potential transfer; however, such camels may progress to develop overt infection and more abundant arthrospore shedding. Khamiev., (1982) 37 examined 200 camels with skin lesions, of which 90 were positive for *T. verrucosum*, which named *T. camelius*. Of these 90 animals, 90% were younger than 2 years. The chlamydiospores of *T. verrucosum* and *T. mentagrophytes* may remain viable for up to 4.5 years in hair and cellular debris scraped off animals and left attached to fomites17. Infected camels have been shown to cause substantial environmental contamination and a significant airborne load of viable fungal elements. Al-Ani et al., (1995) discussed extensively the source of infection of *Trichophyton schoenleinii*, that occurred in 80 younger camels (6months-3 years), in Iraq. They mentioned several suggestions. He stated that the source of infection was not established but could have been from human attendant, introduction of new camel calves into the herd and perpetuated infection within adult camels and spread to susceptible camel calves.

There are several predisposing factors in dermatophytosis. These factors include environment (high humidity, contamination and overcrowding), poor condition (nutritional imbalance, most probably Vitamin A and zinc deficiency and debilitating diseases), age (young) and immunity (prior exposure or immunosuppression. Studies in camels have showed that the prevalence of dermatophytosis to be higher in cold and rainy seasons than in hot and dry seasons ((Fadlelmula et al., 1994; Gudding and Lund, 1995; Rybnikar, (1992).

Pathogenesis

There are different possibilities, when dermatophytes contact the skin of the camels (Figure 1). The fungi may be:

- Rebuff mechanically.
- Failure to initiate residency because of its inadequacy to compete with skin normal flora.

- Initiate residency but doesn't show clinical lesions and become as asymptomatic carrier.
- Initiate residency and show clinical manifestation of the diseases.

The injured skins, lesion scars, are the possible route of entry for the dermatophytes. Arthrospores or conidia cause infection. Resting hairs lack the essential nutrient required for the growth of the organism. The hair invasion by dermatophytes has been studied extensively(Hutton *et al.,* 1978; Kligman, 1956 ; Kligman, 1952; Lepper, 1972; Pier *et al.,*1972). Commonly, dermatophytes do not invade living tissue. The sole pathogen mechanism is the invading the uppermost, non-living, keratinized layer of the skin namely the stratum corneum and produces exo-enzyme keratinase (irritants toxins or allergens). These substance penetrate the living epidermis and enter the dermis, where blood vessels are capable of responding to the threat of toxic or allergenic material and induces the inflammatory reaction at the site of infection (Wawrzkiewicz *et al.,* 1991; Lopez-Martinez *et al.,* 1994; Siesenop and Bohm, 1995; Muhsin *et al.,* 1997).

The traditional signs of inflammatory reactions such as Alopecia, Erythema, papules, scaling, crusting and alopecia (loss of fur) are seen at the infection site. Inflammation causes the pathogen to move away from the site of infection and take residence at a new site. This movement of the organism away from the infection site produces the classical ringed lesion (Dahl,1994) (Figure 2). The infections caused by dermatophytes are commonly introduced to as "tinea" or "ring-worm" infections due to the characteristic ringed lesions (Theodore *et al.,* 2008). The initial residency of dermatophytes led some researcher to describe it as a biological contact dermatitis (Jungerman and Schwartzman, 1972). The dermatophytes cope to maintain their existence on the skin, their survival largely depends on not evoking a severe inflammatory reaction. It manages a long-term evolutionary process and adapt itself to survive on the skin of a particular host and, under ideal parasitic conditions, elaborate minimal amounts of toxins or allergens. Dermatophytosis is a self-limited disease in large animals. The duration of clinical infection is one to four months. Reinfection is uncommon. With animals suffering from severe, chronic, or recurrent dermatophytosis, significant environmental (filth, moisture, or crowding) or immunosuppressive (underlying diseases or deficiency) factors should be suspected.

Clinical signs

The clinical signs of camel dermatophytosis infections are extremely variable in their clinical presentation. There are two clinical types the mild (local lesions) and severe (generalize lesions). The severity of the lesions depends on the several factors such as the age of the camels, the species of the pathogens and immunity of the animals. The classic lesions in most cases in camels are alopecia associated with erythema, Papules, Scaling, and Crusting.
The mild infection is well demarcated as grey-white lesion with active inflammation at the periphery, that is well occurred commonly on the face, legs, neck and head of the animals. Small round alopecic areas are surrounded the lesions. Depending

on the size and duration of the lesion, there may be central crusting or central healing. These lesions may also coalesce and make large lesions.

The severe type is a more generalized. The infection occurs as extensive areas of scarring on head, neck, limbs and flanks. The lesions appear initially as slight scaling of the skin on different parts of the body and head (more common around the mouth and eyes). Two to three weeks later, heavy incrustation on different parts of the body develops, and multiple large lesions may appear in flanks, neck, chest and legs. The lesion typically consists of an area of alopecia and a prominent encrustation accumulation and scale formation (Figure3). Camel suffering from severe dermatophytosis type develops signs of emaciation and weakness. This lesion may initially be confused with mange; however the diagnostic tools will differentiate the diseases (Manefield and Tinson,1996).

Most camel dermatophytosis occurs in cold season (winter) and spontaneous recovery appears in affected camels, where the lesions are starting to regress in size and fibre growth resume after 8-16 weeks in early spring. Meanwhile, the treatment of the camels will speed the recovery. There are several studies that described the clinical appearance of dermatophytosis in camels. In Sudan, Fadlelmula, (1994), presented the survey on camel ringworm. The diseases diagnosed in 217 out of 498 young camel calves under two years old with a peak incidence in autumn and winter. The prevalence among male and female was similar and the lesions were observed mainly on the head, neck and shoulder with frequent extension to the flanks and limbs. In this study, the researcher stated the isolation of *Trichophyton verrucosum* in pure culture for the first time from camel ringworm in the Sudan. Wisal, and Salim, (2010) presented also dermatophytes outbreak in one Hundred thirty six camels in Sudan. They isolated seventy seven *Trichophyton verrucosum*, 47 *Trichophyton mentagrophytes*, 9 *Trichophyton schoenlenii* and 3 *Trichophyton tonsurans*. Both female and male camels were susceptible and camels less than 3 year old were more susceptible to infection. The skin lesions were extremely variable in distribution from multifocal to generalized lesions. The typical lesions were circular with peripheral expansion and central-like covered by grey powdery crust. Occasionally, lesions may spread to the periphery, become confluence and produce a moth- eaten appearance of the fur.

In Saudi Arabia, Gitao *et al.,* (1998), described mixed infection of *Microsporum gypseum* and *Dermatophilus congolensis* in camels reared on a dairy farm. Severe lesions demonstrated in both calves and young camels. The discrete, circumscribed, crusty and hairless lesions were observed on the neck and forelegs of the calves. However, camels of varying ages showed extensive hair matting with crusty, hairless lesions, especially on the flanks. In Iraq, the clinical signs of dermatophytosis of natural and experimental *T. schoenleinii* was described by Al-Ani *et al*., (1995), in one-humped camels in the desert near Baghdad. Slight scaling of the skin on the head and around the mouth and eyes was the initial clinical signs that appeared on the camels in this outbreak. Heavy incrustation on different parts of the body appeared later. Within 2-4 weeks, new multiple lesions of 5-12 cm in diameter were developed in other areas including the neck, chest, and legs. The lesions typically consisted of an area of alopecia and a prominent whitish asbestos-like accumulation of scales. Emaciation and weakness were appeared on the affected camels. Same clinical features appeared on the experimentally infected camels.

Spontaneously recovery was also observed in some affected camels. The lesions regressed in size and hair growth resumed after 8-16 weeks in early spring.
In India, (Tuteja *et al.,* 2013), described skin infections in camel caused by *Epidermatophyton floccosum and Scopulariopsis brevicaulis* , which occurred particularly due to high rainfall and high humidity in the environment along with diurnal temperature variations. The camel infected with *Epidermatophyton floccosum showed* fast spreading lesions and peculiar as if hairs were burnt with fire leaving behind ash deposit over the skin. The lesion were observed throughout the body. All ages of the camel were affected but calves were more severely affected. The pronounced dryness of the skin coat was observed and alopecia was seen after lesion necrosis. The affected camels suffered from itching, uneasiness and resulted in weakness and debility of the animals. Whereas the camels infected with *Scopulariopsis brevicaulis* showed several large (5cm in diameter) hyperkeratotic nodules on the abdomen. The lesions more observed under the hairy portion of the skin. Incrustation of the nodules occurred after 15 days which gave appearance of patchy skin necrosis.

Diagnosis

The contagious and zoonotic nature of dermatophytosis obliges veterinarians to maintain a high index of suspicion of this disease. Dermatophytosis should be suspected in any camels showing lesions comprising combinations of alopecia, erythema, papules, scaling, and crusting (Robert & Pihet, 2008). The length, complexity, potential toxicity, and cost of treatment required depend on accurate and early diagnosis. Different methods have used to make a confirmed diagnosis of dermatophytosis. In addition to conventional methods (Robert & Pihet, 2008), molecular (Elewski *et al.,* 2002; Kanbe et al., 2008) methods have been used extensively in recent years.
The World Organization For Animal Health (OIE) (2008), set up an Ad Hoc Group on diseases of Camelids to determine the OIE-listed diseases that should be considered significant in camelids. In addition to the diseases of other domestic animals for which camelids could potentially be pathogen carriers. Camel diseases divide into three groups according to OIE Ad Hoc Group:

1. Significant diseases
2. Diseases for which camelids are potential pathogen carriers
3. Minor or non-significant diseases

Fungal diseases classified as one of the significant diseases.
The difficulty in the diagnosis of dermatophytosis in the camels depends primarily on two factors. First is the absence of standardization of the collection of clinical specimens, because of the hardness of the skin of the camels. Second, is related to the mycological techniques, and the lack of commercial availability for most of the diagnostic reagents needed in camels.
The intention in diagnosing dermatophytosis is to investigate the infiltration of the epidermis or hair shaft by a dermatophyte. Wood's lamp examination, direct microscopy, culture, and biopsy, consider as the principal complementary diagnostic methods (conventional methods), which should be routinely performed. A biopsy specimen can be useful in unusual presentations, and the results may

surprise the clinician when symptoms suggest another diagnosis. None of these is always reliable. However, histopathology is required in some cases for optimum sensitivity and specificity (Sparkes et al., 1993).

Specimen Collection

A sufficient amount of skin samples should be taken correctly from the edge of the infected area, which coincide to the active zone of the lesion. Hair is also collected for the isolation of dermatophytes. The suspected ringworm lesion and hair samples should be collected by the specialist veterinarian and experienced staff. The samples should be collected before any local or systemic antifungal treatment, to ensure the efficiency of mycological examination. The samples should be submitted with a filled history sheet including all the information concerning the sick animal.
A stubble and broken hair at the advancing periphery of an active lesion should be collected using forceps. Whereas, skin scraping from the lesion must be taken by sterile scalpel blade or skin Plucking. The skin should be disinfected with 70% ethanol before sampling for mycological culture.

Direct microscopic examination

Clearing technique is necessary for human's ringworm because of the endothirx infection patterns, however, most animal fungal infection are dominated by ectothrix arthrospore patterns, and can be examined by simply suspending the specimens in mineral oil. However, most diagnostic laboratory still use clearing method. Simply, 20% potassium hydroxide (KOH) add to the hair and keratin in small test tube. The test tube is heated for 15-20 seconds (avoid boiling) or allowed to stand for 30 minutes at room temperature. Then few drops of precipitate are placed on slide and cover slide is gently placed and then examine under microscope. Characteristic hyphae and/or arthrospores might be seen. This test is required considerable skill, and failure to observe hyphae or spores does not exclude the diagnosis; however, the rapid diagnosis from microscope enables treatment and control methods to be initiated without the delay associated with fungal culture.

Fungal culture

Identify the species of dermatophyte is done by fungal cultures, which, can be useful in understanding the source of the infection and targeting preventive measures appropriately. Fungal culture is necessary for uncertain, diagnosis in direct microscopic examination, or the infection is resistant to standard treatment. All fungi require several specific selective medium for growth and reproduction. The requirements for growth are less stringent than for sporulation, so it is often necessary to try various types of media when attempting to identify a fungus in culture. Sabouraud's dextrose agar containing antibiotic(s) (chloramphenicol ± gentamicine) and cycloheximide (Actidione) and brain-heart infusion agar, Dermatophyte Test Medium (DTM), either in petri dishes or screw top tubes are commonly used in veterinary mycology as a primary isolation media. The media may be enriched with 5% to 10% sheep blood to support the growth of certain fungi.

The incorporation of cycloheximide in the culture medium will prevent the growth of a majority of moulds, but also of some yeast that could restrain the recovery of dermatophytes.

Ready-to-use Sabouraud's agar plates or slants are commercially available under various names from several laboratories (such as Himedia, bioMe´rieux, Bio-Rad, AES, Oxoid or Becton-Dickinson). However, great variations may be observed from one manufacturer to another in composition and pH of their culture medium, and, therefore, in performances of the medium regarding its ability to support fungal growth (Brun *et al.,* 2001). Most fungi also thrive on Potato Dextrose Agar (PDA), but this can be too rich for many fungi, so that excessive mycelial growth is obtained at the expense of sporulation. Some dermatophytes that cause disease in camelids have special nutritional or incubation requirements.

Fungal cultures should be examined daily for the first five days. Colonies appear in 5 days to 4 weeks, depending on the organism. Colony morphology can differ with the medium. Descriptions are usually based on Sabouraud agar or other fungal culture media that also be used for isolation. Dermatophyte species can be identified by the colony morphology; the appearance of microconidia, macroconidia and other microscopic structures; biochemical characteristics such as urease production; and nutritional requirements. Specialized tests such as the ability to penetrate hairs in vitro, or mating tests (that are usually available only at reference laboratories) may be used occasionally. Differential media (e.g., bromocresol purple - milk solids glucose) can be helpful during differentiation.

A slide prepares from the fungal culture overflow with water containing Tween 80, bromocresol purple or lactophenol cotton blue stains can be used to examine the fungal structures. Hyphae and conidia from mature fungal colony can be seen intertwined with each other's on a microscope slide.

Cultural characteristics of dermatophytes spp that have been isolated from camelid's skin lesions worldwide are described briefly in text book and literature. *Trichophyton verrucosum* isolated from skin and hair taken from the younger camels was described by Kuten, (1986). The fungus showed slow-growing, glabrous, white to ochraceous colonies with abundant chlamydospores and antler-like branching hyphae. Stimulation of growth and microconidia was seen on the enriched basal medium with thiamine hydrochloride and inositol. However, older infected camels revealed *T. mentagrophytes* colonies. These colonies were white-yellowish powdery colonies with dark red pigment on the reverse side of the colonies. Microscopically, fungus showed clusters and lateral spherical microconidia and club-shaped to spindle shaped macroconidia with 4 or more cells, as well as many spirals.

Mohammod, (1993) were recovered and described sixteen species belonging to nine genera of keratinophilic and cycloheximide-resistant fungi from diseased camels. Al-Ani *et al.,* (1995) was also described the colony morphology of T. schoenleinii isolated from a typical lesion area of alopecia and prominent whitish asbestos-like accumulation of scales. Inoculated plates that incubated at 25 0C showed growth after 10 days. The colonies were similar to those described for T. schoenleinii in human and other species. The colonies appeared as small raised white, leathery types and in time the colour became tan to brown with folded surfaces. T. schoenleinii hyphae appeared in the microscopic examination as septate hyphae with very few microconidia while the macroconidia were absent.

Gitao *et al.,* (1998), described the Microsporum gypsium isolated from camels in Saudi Arabia. While full description and identification of dermatophytes from infected Camels also presented by Wisal *et al.,* (2010).

(Table 1) . Isolation and identification of Dermatophytes from infected Camels. Sudan J. Vet Res. (2010).25: 94-53) .

Species	Direct examination	Macroscopic appearance	Microscopic Features	Urease test
T. verrucosum	Ectothrix	Cream, folded, heaped, button like and waxy	Chains of chlamydospores	*Negative*
T. mentagrophyte	Ectothrix	Ggranular, white in the obverse and brown in the reverse, hard in texture	*Coiled spiral hyphae and numerous microconidia*	Positive
T. schoenlenii	Favic hyphae	Glaborus, cream to grey and yellow to light brown in the reverse	Antler hyphae	*Positive*

Tricho phyton tonsur ans	*End othri x*	Velv ety, folde d, heap ed, pale yello w obve rse and dark yello w on the rever se	Numer ous microc onidia differen t size and shape	*P os iti ve*

Tuteja *et al.,* (2013) was isolated and described *Epidermatophyton floccosum* and *Scopulariopsis brevicaulis* from 2 camel herd infection in India. The *Epidermatophyton floccosum* grew moderately rapidly and became mature within 10 days following incubation at 28 ^{0}C. The colour of the lesions was brownish yellow to olive grey or Khaki from the front and orange to brown with an occasional yellow border from the reverse. Surface was flat and grainy initially and became radically grooved and velvety by aging. Microscopically septate, hyaline hyphae, thin walled macroconidia, 3-5 celled, smooth and clavate shaped with rounded ends, single or in clusters. Chlamydoconidium like cells, as well as arthroconidia, are common in older cultures.

The *Scopulariopsis brevicaulis* grew also moderately rapidly and were granular to powdery. Front colour was white initially and became light brown or buff tan in time. Reverse colour is usually tan with brownish centre. Microscopically septate hyphae, conidiophores are hyphae-like and simple or branched. Lemon-shaped, roughened conidia with truncated bases produced from the tips of annellidic conidiogenous cells. The annellides were produced songly or in penicillate heads. These were cylindrical and slightly swollen as has been reported by De-hoog *et al.,* (2000) and Sutton *et al.,* (1998).

Full description of the growth characteristic of species dermatophytes that caused camel dermal mycoses was made by (Tuteja *et al.,* 2013). The samples were collected during five years from camel rearing villages in the Rajasthan state in India. Out of the total 207 fungal isolates from camel skin infections included 33 isolates of *Microsporum* spp. and 35 of *Trichophyton* spp. Table(2).

Species		Macrosc opic appearan ce	Microscopic Features
Microspo rum Spp. In general, colonies	*M. audoinii*	Flat, spreadin g, greyish-white to	Rarely produced Macroconidi a and Microconidi

are glabrous, downy, wooly or powdery. Colonies growth on SDCA at ^{0}28C may be slow or rapid , colonies size and colour dependin g on species. Septate hyphae, microcoid ia and macrocon idia are produced. Conidiop hores are hyphae are produced in some species.		light tan-white colonies having a dense suede-like to downy surface (mouse fur in texture), reverse (yellow-brown to reddish-brown) some strains showed no reverse pigment.	a. Sterile culture or thick-walled terminal or intercalary chlamydoco nidia are produced.
	M.Canis	Flat, spreadin g, white-creamy, dense cottony surface (some showing radial grooves) , reverse (bright-golden yellow to brownis h yellow but non - pigment ed also occurred).	Typically, spindle-shaped with 5-15 cells Macroconidi a, verrucose,th ick-walled with terminal knob. Few pyriform to clavate microcondia were also observed.
	M. nanum	Powdery , cottony, thin, moderat ely fast growing , spreadin g, velvety	Septate hyphae, 1-4 celled (usually 2), thin walled and oval-elliptical Macroconidi a, club-shaped vay abundance

		or flat some showing radial or shallow furrows, white to dark beige from front, reddish-brown from reverse.	Microconidia.
	M. ferrugineum	Slow growing, waxy, glabrous, convoluted thallus, cream-buff surface, rapidly becoming downy and pleomorphic.	Irregular branching hyphae, prominent cross walls "bamboo hyphae", chlamydoconidia.
Trichophyton Spp. In general, colonies grow slowly to moderately rapid. Septate hyaline hyphae, conidiophores are poorly differentiated from the hyphae, predominant microconidia are one-celled and	*T. verrucosum*	Slow-growing, small, button-or- disc-shaped, white-cream, suede-like-velvety surface, raised centre with some merged growth, reverse (non-pigmented to yellow)	Irregular hyphae with many terminal and intercalary chlamydospores (often chains). Some hyphae have broad –club-shaped – occasionally divided tips called "antler" effect. Rarely produced Macroconidia with characteristic tail-or-string bean shape.

round or pyriform in shape and numerous , solitary or arranged in clusters , very few macrocon idia are multicellu lar (2-or more-celled), smooth, thin or thick-walled and cylindrica l, clavate or cigar-shaped, arthroconi dia are observed.			
	T. mentagrop hytes	Flat, white-cream, powdery - granular surface, central folding-or-raised central tufts or pleomor phic suede - like-to-downy areas, reverse (yellow-brown to reddish-brown)	Microconidi a appears as dense clusters, numerous single-celled , hyaline, smooth-walled and predominant ly spherical to sub-spherical in shape, clavate to pyriform forms occasionally occurs. Varying numbers of spherical chlamydoco nidia, spiral hyphae and smooth, thin-walled, clavate shaped, multicelled macroconidi a may also be present.
	T.schoenle inii	Slow growing, waxy-or-suede-like with a deeply folded honey-comb-like cream to orange brown thallus and some subsurfa ce growth, difficulti es to maintain	No Macroconidi a and Microconidi a are seen in routine culture , numerous chlamydoco nidia, characteristi c antler"nail head"hypha e also known as favic chandeliers may be present in older cultures.

		typical convoluted form and rapidly become flat and downy, No reverse pigmentation is present,	
	T. equinum	Flat, some may develop white-buff, gentle folds-or-radial grooves, suede-like-downy in texture, deep-yellow submerged fringe and reveres dark red.	Abundant Microconidia which may be clavate to pyriform and sessile or spherical and stalked are formed laterally along the hyphae. Macroconidia are only rarely produced, clavate , smooth, thin-walled and variable size. Nodular organs might be present and Microconidia often undergo a transformation to produce abundant chlamydoconidia in old cultures.
	T. concentricum	Slow-growing, raised, folded, glabrous becoming suede-like, white-	Broad, much-branched, irregular, often segmented, septate hyphae (having

		cream, reverse(buff-yellow-brown to brown)	"antler" tips, chlamydoconidia presents in older culture, Microconidia and Macroconidia are not usually present produced , some isolates occasionally produce clavate to pyriform microconidia, hyphal segments may artificially resemble macroconidia.
	T. tonsurans	Moderately slow growth, highly variable suede-like, powdery or velvety, flat with a raised centre or folded, often with radial grooves. White, beige, greyish, pale or sulphur yellow, roseor brownish on surface , reverse (varies	Broad , irregular, much branched with numerous septa hyphae , numerous various shapes and sizes (pyriform, tear drop, club shaped or balloon shaped) Microconidia, intercalary and terminal chlamydospores found in old culture, rare and smooth walled distorted macroconidia .

		from yellow-brown to reddish-brown to deep mahogany.	
	T. violaceum	Slow growing, glabrous or waxy, heaped, folded, deep violet ,cultures often become pleomorphic.	Hyphae are relatively broad, tortuous, much branched and distorted. Young hyphae stain well in lactophenol cotton blue and show small central fat globules and granules. Numerous chlamydoconidia are usually present, in older cultures.
	T. Soudanense	Slow-growing, flat-folded, suede-like surface, broad fringe of submerged growth, reverse(deep apricot-orange).	Hyphae often show reflexive or right-angle branching, pyriform microconidia and numerous chlamydoconidia are often found in older cultures.
	T. rubrum	Slow, hyper-pigmented growth, showing a violet to red-	Few pyriform lateral microconidia, pencil shaped macroconidia,

		violet-red glabrous surface with radial furrows, reverse (deep violet to red-violet)	arthroconidia produced from hyphae and macroconidia.

Histopathology

Histology may be useful and has been proposed by some authors as a simple diagnostic for fungal infection in camels. Indeed, histological examination of skin biopsies stain with periodic acid Schiff (PAS) and Gomori's methenamine silver special stains, Acid Orcein-Giemsa (AOG), in addition to haematoxylin and eosin (HE) stain ,seems to be the more sensitive method for the of diagnosis of dermatophytes.
The histopathologic features of dermatophytosis are as variable as the clinical lesions. There is no diagnostic characteristic histopathological appearance for dermatophytosis. However, the most histopathological features seen in dermatophytosis are classified as (Scott, 1988):

- Perifollicullitis, folliculitis and furunculosis.
- Superficial perivascular dermatitis (spongiotic or hyperplastic) with orthokeratotic or parakeratotic hyperkeratosis of the epidermis and hair follicles.
- Intraepidermal vesicular (sponigiotic) or pustular dermatitis.

Some research article described the histopathological features of the skin biopsies from camels infected with dermatophytosis. Skin sections showed hyperkeratotic areas with sub-acute inflammation, a severe invasion of fungal hyphae (Fig. lb) and many hairs with ectothrix spores (Kuttin & Beemer, 1975). Sections of skin with a mixed infection of *D. congolensis* and *M. gypseum* (Gitao *et al.,* 1998) revealed congestion, hyperkeratosis with abundant keratinaceous debris. The epidermis was thickened, and the dermis diffusely infiltrated with polymorphonuclear leucocytes. The keratinised layers were invaded by abundant *D. congolensis* filaments and coccoid forms featuring transverse and longitudinal divisions. Sections stained with PAS revealed abundant mycotic filaments in the epidermis. Histopathological changes of mixed dermatomycosis and mange infection in camels accompanied with chronic granulomatous hidradenitis also described (Al-Salihi *et al.,* 2013). An examination of the skin sections revealed dermatitis characterised by acanthosis with marked parakeratosis, hyperkeratosis and crust formation, rete-pegs, hyperplastic changes in sebaceous glands and hair follicles cells, granulomatous

hidradenitis and infiltration with eosinophils, lymphocytes, macrophages and neutrophils. Sections stained with periodic acid-Schiff (PAS) and Gomori's Methenamine silver (GMS) stain, revealed large numbers of fungal arthrospores and hyphae coloured bright magenta with PAS and black with GMS.

Molecular biological technology in the Diagnosis of Dermatophytosis

Conventional method in the identification of dermatophyte species is complicated and laborious due to the morphological similarity, variability, and polymorphism shown by dermatophytes. It is based on macroscopic and microscopic observations of their morphological features. Thus, accurate identification is time consuming and requires a significant level of knowledge and technological expertise. Some laboratory use of the mating test as a means of identification, however, it is not practical because many of the anamorphic species lack a teleomorph. The scientists focused on molecular analyses dermatophyte genomes in the diagnosis that is the simple and accurate identification techniques and would clear several problems in the traditional morphology based taxonomy. With these expectations, many investigators have focused their research on the nucleic acids of dermatophytes. Davidson *et al*., (1980) analysed the G + C content of chromosomal DNA isolated from 34 dermatophyte species. It was belonging to the three genera, *Trichophyton*, *Microsporum*, and *Epidermophyton* and reported that it ranged from 48.7% to 50.3% and is narrow when compared with the range of 48–61% reported in a single genus, *Aspergillus*. This observation indicates a genetic homogeneity among the dermatophytes in contrast to their phenotypic and ecological variation. Subsequently many investigators have focused on mitochondrial DNA (mtDNA) and ribosomal DNA (rDNA) of dermatophytes and gradually determined the phylogenetic relationships among dermatophyte species. These data have widely contributed to the development of techniques for the identification and epidemiology of dermatophytes based on molecular technology, as reviewed by Blanz et al., (2000) and Kac, (2000). Further development of molecular diagnosis of dermatophytosis requires the investigation of additional molecular markers for diagnostic tools targeting multiple loci as well as the improvement of techniques (Toshio, 2008).

Rapid molecular diagnosis techniques of dermatophytes have been used successfully in horses. Some investigators used a rapid DNA extraction method directly from the hair samples and the total 30 DNA extracts were subjected to PCR using specific primers for dermatophytes group. This PCR resulted in 22 (73.3%) positive samples within 8 hours (Heidy *et al.,* 2013).

Another investigators compared between molecular and traditional diagnostic methods in the diagnosis of dermatophytosis thirty-eight racehorses. PCR is fingerprinting profiles using simple repetitive (GACA) 4 primers showed that all diagnosed horses had the same pattern profile. Oligonucleotide sequencing of CHS1 gene PCR products confirmed *Trichophyton mentagrophytes* as the infectious agent (Chung *et al.,* 2010).

The PCR-based molecular diagnostic method is an accurate, sensitive and specific and offers very rapid precise diagnosis of dermatophytosis in horses (Heidy *et al.,*

2013; Chung *et al.,* 2010) and rabbits (Claudia *et al.,* 2012) as well as in human (Atsushi *et al.,* 2004). Camel dermatophytosis is still needed for the development of more promising diagnostic methods, including molecular techniques that, can be detected directly in clinical samples. Rapid field diagnosis of camel dermatophytosis is very essential. Camels are always lived out of reach of the diagnostic laboratory and rapid and appropriate identification of the causative species will be helpful in the treatment as well as in control by establishing the source of infection and thereby plans to manage and control it.

Differential diagnosis

The diagnosis of ringworm depends on evidence of infection, the appearance of the characteristic lesions and the presence of fungal mycelia and spores. Diagnostic confirmation is made by demonstration of fungal elements in a scraping or biopsy. The owner's camel well knows ringworm and they are able to differentiate this dermatitis from other skin infections. The differential diagnosis list of ringworm, which may be confused with diseases having similar clinical profiles are:

- Zn deficiency (parakeratosis) by tenacious thick crusts and response to treatment with minerals.
- Sarcoptic and Psoroptic mange, in which mites can be demonstrated in scrapings.

Treatment

Dermatophytosis considers as self-limiting disease, with spontaneous remission occurring within four months. The successful treatment of the disease requires always proper diagnosis. Many topical treatments have been reported to be successful in camels, but because spontaneous recovery is common, claims of efficacy are difficult to substantiate. Fungi are eukaryotic and have a mechanism similar to mammalian cell that's why the development of novel and efficient antifungal drugs is still lagging behind. Hence it becomes very difficult to develop an antifungal agent that is more specific in targeting the fungi alone without any damage to infected patients. A variety of topical and oral antifungal drugs are used to treat dermatophyte infections. The contagious and zoonotic nature of this disease makes treatment highly desirable for Valuable individual farm animals and camels, because this may well limit both progression of existing lesions and spread to others in the herd. A combination of topical and systemic therapy, along with clipping of the fur, is the optimal approach in animals. Clipping the fur from affected areas may assist with the mechanical removal of infected furs and aid the penetration of the topical antifungal drug onto the skin surface, although care should be taken to limit abrasions that might promote new lesions in the shorter term. Thick crusts should be removed gently with a brush, and the material burned or disinfected with hypochlorite solution. Before the treatment, lesions should also be clean with warm soapy water. The topical antifungal agents are available and approved by drug regulatory authorities for veterinary use vary markedly between countries. Topical application is of particular value in targeting fungal elements.A variety of common

fungicidal and fungistatic agents such as iodine, 5% sulfur in sesame oil (w/v), 5% salicylic acid, coal tar phenols (3.25%) with copper acetate (0.58%) and hydroxyquinolines may be applied topically as ringworm ointments onto the affected areas. Treatment options depend on the limitations on the use of some agents in animals meant for slaughter. Individual lesions can be treated with miconazole or clotrimazole lotions. These topical treatments are probably of greater value in the early stages of an outbreak when the lesions are small and few. Ainsworth and Austwick, (1973) used Captan@, in the treatment of camels dermatophytosis. It is a fungicide for ornamental plants. They sprayed on infected animals as a solution of 1:200. Captan@ mixture is stable for one week after mixing and the solution should be applied to the lesions and surrounding areas for 2 weeks. Systemic therapy is recommended for use in farm animals and should give for the infected animals as a complementary step of therapy in most cases. In cattle, it includes the intravenous injection of sodium iodide (1 g/14 kg body weight) as a 10% solution repeated on several occasions. There are pertaining reports of beneficial effects of griseofulvin in ruminants and horses. However, griseofulvin is not recommended in camel because of its side effects such as nausea and diarrhea (Schwartz and Dioli,1992) [100]. Griseofulvin is also teratogenic and should not be given to pregnant animals. Owners should wear gloves when handling the tablets. In addition, this drug does not have a minimum meat residue level under European Union legislation and cannot be used in food producing animals, in this area.

Control

Hygiene

Infected animal acts to widespread of the causative agent in the area as well as to the healthy animals and failure to control on ringworm outbreak. Early diagnosis and isolation and treatment of infected animals are necessary if the disease is to be controlled. Cleaning and disinfection of infected areas, stables and equipment with a commercial detergent or a strong solution (2.5-5 %) of the phenolic disinfectant, 5% lime sulfur, 5% formalin, 3% captan or 5% sodium hypochlorite is advisable to avoid recurrence of infection.

Vaccination

The immunoprophylaxis of dermatophytosis in animals has recently been the subject of a detailed review (Arve *et al.,* 2008) . Most European countries and Scandinavia have achieved a great deal of success in preventing ringworm infection in cattle and horses. Live attenuated but virulent strains of *T verrucosum* that produce abundant microconidia have been used in extraordinarily successful mass vaccination campaigns, in cattle herds in former Eastern block countries and Norway. Vaccines include those containing highly immunogenic, non-virulent strains, or attenuated (Gordon and Bond, 1996) strains of fungi, or those killed vaccines containing specific fractions of mycelia. Vaccination of all animals in the group is recommended, and isolation and treatment of infected animals and disinfection of premises and gear must be carried out at the same time. In camel

vaccination programs against *Trichophyton* spp. and *Microsporum* spp. have been reported from Kazakhstan (Toleutajewa, 1994). Commercial Camelvac Tricho@ (IDT Dessau-Tornau ,Germany), has been successful used in the Republic of Kazakhstan. Before vaccination, ringworm was contagious in Bactrians and reached to 60.1% in less than one year Bactrians, after vaccination no ringworm cases reoccurred for several years. This vaccine is used also for prophylactic purpose with very good success. The Camelvac Tricho@ has also recently been successfully used in several camel herds in the UAE. Young dromedaries with ringworm lesions were vaccinated once. The lesions receded within 14 days and disappeared after 4 weeks.

Nutrition

Supplementation of the diet, particularly with vitamin A and zinc to young housed animals, should be encouraged as a preventive measure, because the disease to be a tendency for the poorly fed animals. Although ringworm can also occurred in well-nourished animal.

Skin Candidiasis and miscellaneous fungal infection

Candida albicans is a common microbial inhabitant of the respiratory, alimentary, and genital tracts (Biberstein *et al.,* 1999; Ginn *et al.,* 2007). In a variety of species, C albicans can be associated with cutaneous, systemic, and localized infections 1. It is usually sporadic infections and cause non-specific syndromes because of variation in the organs in which they localize. Candidiasis (moniliasis) is a common sporadic disease of the digestive tract caused by the yeast Candida spp. (most commonly C. albicans). In domestic mammals and humans, cutaneous infection with Candida spp is often associated with underlying immune suppression (Gross *et al.,* 2005; Mays *et al.,* 2006; Scott, 1988).

There is only few report of infection with a Candida sp in camelids. One case of gastric candidiasis had been reported in a neonatal llama, in Europe (Hajsig *et al.,* 1985). Skin lesion caused by C. albicans has also been diagnosed in young dromedary calves in the UAE after prolonged treatment with antibiotics (Wernery and Kaaden, 2002). The lesions caused C. albicans are resembled D. congolensis infections. The camel calves (6-week-old) had developed thick crusts near the hump in which hyphae were demonstrated with PAS stain. Fungal dermatitis due to candida albicans have also been reported in an 8-year-old castrated male llama(Lamm *et al.,* 2009). The llama were present with large, locally extensive areas of thick, coalescing crusts in sparsely haired areas of the axillary, inguinal, and perineal areas and around the muzzle. The crusts were firm and moist and could be manipulated away from the skin. Removing of the crusts revealed moist and red accompanied with a foul odor underlying skin. Scattered small pustules were also recognized in the affected areas. A pure culture of Candida albicans was obtained from the submitted fresh skin samples. The histological features of the punch biopsy specimens obtained from the axillary region were also described. There were marked orthokeratotic to parakeratotic hyperkeratosis with thick serocellular crusts composed of layered degenerate neutrophils, small numbers of RBCs, and myriad yeast organisms. The yeast organisms were 5 to 7 μm in diameter; approximately 5- to 7-μm-diameter pseudohyphae with nonparallel walls were also evident. The

underlying epidermis was moderately to markedly hyperplastic with multifocal areas of spongiosis, neutrophil exocytosis, and large intraepidermal pustules composed of degenerate neutrophils. Within the underlying dermis, there was a marked, multifocal perivascular infiltrate of neutrophils, macrophages, lymphocytes, and plasma cells. According to histological features, the case was diagnosed as "severe, diffuse suppurative dermatitis with serocellular crusting, epidermal hyperplasia, and intralesional yeast and pseudohyphae in haired skin of the axilla." The llama was treated with daily topical application of nystatinc and chlorhexidine acetated ointments to the affected skin regions. Following treatment for 60 days, the llama fully recovered with regrowth of hair within the affected regions. Another female llama in the herd with similar, albeit less severe, clinical signs was treated similarly and responded completely to treatment.
Naturally skin candidiasis reported in dromedary calves, in India 2012 (Tuteja *et al.,* 2012). These cases of skin candidiasis in camel calves were treated topically with three formulations consisting of 2% potassium iodide; 6% sulphur in mustard oil; and 6% sulphur and 3% salicylic acid in mustard oil. All treatments showed ability to relief and minimise the morbidity in young camel calves due to skin candidiasis. Infections with Coccidioides immitis and Conidiobolus coronatus in camelids have also been reported (Rosychuk, 1994; Rosychuk, 1989; Moll *et al.,* 1992).

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