EPIDEMIOLOGY, CLINICAL PRESENTATION, DIAGNOSIS AND TREATMENT OF DERMATOPHYTOSIS

Supported by tetfund

[1,2]Ukhureigbe O.M,[2] Moro D.D, [2]Akinyemi K.O, [2]Ajoseh S.O

[1:] Department of Microbiology, Faculty of Science, Federal University, Oye Ekiti, Ekiti State;
[2:]Department of Microbiology, Faculty of Science, Lagos State University, Ojo, Lagos, Nigeria;
Corresponding author: ukhureigbemiriam1983@gmail.com

Received: September 14, 2023, **Accepted:** November 28, 2023

Abstract: *Trichophyton* (most common), *Epidermophyton* and *Microsporum* species are dermatophytes implicated in dermatophytosis also referred to as tinea or ringworm. These causative agents usually exist in the anamorph and teleomorph phases. Hot and humid climates usually experienced in Africa, Asia and Europe are risk factors that facilitate the transmission of this cankerworm which accounts for 3-4% of dermatological cases worldwide. The population at risk has increased, with a prevalence record of, 20%-25% around the globe and 29% in Nigeria respectively. Transmission occurs through contact with fomites, man, animals and soil. The clinical presentation of tinea pedis (ringworm of the feet), tinea capitis (ringworm of the scalp), and tinea mannum (ringworm of the palm) are cracks, black dots, and the formation of blisters respectively. Dermatophytes' arthroconidia attach to the epithelium after which they germinate to hyphae which eventually invade the host cell destroying the keratin layer of the epidermis. Diagnostic procedures for tinea include microscopy, culture, biochemical and molecular assay. Terbinafin is the first-line medication for the treatment of dermatophytosis; other antifungals such as fluconazole, ketoconazole and griseofulvin are also used in the treatment of dermatophyte; Management entails the adoption of personal hygiene, treatment of carriers and monitoring of liver enzyme. Creation of awareness, development of efficient identification techniques and adoption of reference anti-fungal susceptibility testing methods are preventive strategies. There is a need for rapid and efficient methods for the detection of dermatophytes and prompt interventional strategies to stem the tide of tinea in our environment.

Keywords: Allylamine, Arthroconidia, Dermatophytosis, Tinea, Transmission

Introduction:

Fungal infections have increased in frequency over the past two decades as a result of the rising number of immunocompromised patients. It is also estimated that 30 to 70% of adults are asymptomatic carriers of fungal pathogens. Previously, *Candida*, *Cryptococcus* and *Aspergillus* were the major human fungal pathogens but other fungal pathogens such as filamentous fungi (dermatophytes) are emerging (Saunte *et al*., 2017).

Dermatophyte is a group of closely related filamentous fungi that can damage and utilize keratin found in the skin, hair, and nails (Alshawa *et al*., 2012). They are cosmopolitan and encompass more than 50 species from the genera *Trichophyton, Microsporum, Epidermophyton, Arthroderma, Nannizzia, Lophophyton,* and *Paraphyton* (De hoog *et al.*, 2017). These organisms develop tubular structures referred to as hyphae, made of inter-connected aligned fungal cells bordered by an uninterrupted wall. The hyphae are regularly divided into cell compartments by septa made of peripheral rings with a composition similar to that of the cell wall. Pores through these septa allow communication between the cytoplasm of multiple cell compartments along the entire hyphae (Deacon, 2006).

Dermatophytes grow best in warm and humid environments and are, therefore, common in tropical and subtropical regions such as India and Nigeria (Seebacher *et al*., 2016).

Different species of dermatophytes are host-specific, predominate in different epidemiological locations and present different clinical pictures.

Dermatophytosis is an infection caused by dermatophytic fungi in the keratinized tissues which are transferred from animal (zoophilic dermatophytes) and soil (geophilic dermatophytes) to man or through direct infection by personal contact (anthropophilic dermatophytes) (Grumbt *et al*., 2013). The hot and humid climate in tropical and sub-tropical countries like Egypt and Nigeria makes dermatophytosis a very common fungal skin infection. Clinically, dermatophytosis can be classified depending on the part of the body affected. These include tinea capitis (scalp infection), tinea corporis (infection of the trunk), tinea ungunium (nail infection), tinea cruris (infection of the groin), tinea pedis or athlete's foot (infection of the feet), and tinea barbae (infection of the beard areas of the face). These cutaneous mycoses affect 20% to 25% of the world's population (Havlickova *et al*., 2008). Generally, they are superficial infections, but in immunocompromised patients, they are experienced as disseminated diseases. The gross appearance of lesions produced by dermatophytes includes an outer ring of active, progressing infection with central healing within the ring accompanied by itching, redness, scaling, or fissuring of the skin (Patel and Schwartz, 2017). Symptoms typically appear between 4- and 14 days following exposure. Dermatophytic infection is often confused with other skin infections due to similarity in symptoms manifestation, thus, culminating in misdiagnosis and mismanagement (Yadav *et al*., 2013). Most skin infections by dermatophytes, especially *Trichophyton* spp., are successfully treated using terbinafine, an allylamine which is the first-line oral medication for the treatment of such infections (Hay, 2015). Moreover, most anti-fungal drugs commonly used to treat dermatophytosis target the ergosterol biosynthetic pathway. Imidazoles such as econazole and triazole such

as itraconazole inhibits lanosterol 14-α-demethylase, which leads to the accumulation of sterol precursors and results in altered plasma membrane structure and function (Jun *et al*., 2014).

Epidemiology of Dermatophytosis

Dermatophytosis, the most common fungal infection in humans, is responsible for 3%-4% of dermatological cases, with a prevalence estimated around 20%-25% (Zhan and Liu, 2017). Its prevalence is continuously increasing due to increased risk factors such as sports activities, type 2 diabetes, vascular diseases, or ageing. Modern mobility further increases the dissemination of anthropophilic dermatophytes that extend to previously poorly affected geographical areas (Hayette and Sacheli, 2015). Tinea capitis is present in up to 19.7% of the general population in developing countries and has been reported to be present in more than 30% of children at certain grade levels in some urban areas of the United States. Among the species capable of infecting humans, *Trichophyton rubrum* is the most common, being responsible for 50%-90% of dermatophytoses in humans (Lee *et al.*,2015). The annual health expense of dermatophytosis is estimated to be more than 500 million US dollars (Achterman and White, 2012). *T. violaceum* is the major cause of tinea capitis in South Africa (Morar *et al*., 2004). The high prevalence rate of tinea pedis has been associated with increased urbanization, sports, and the use of occlusive footwear. Occurrence rates of 22-31%, 21- 72.9%, and 16.4-58%, have been reported among Marathon runners, miners and soldiers respectively. The continuous increase in occurrence is due to increased risk factors such as sports, type 2 diabetes, vascular diseases or ageing, HIV- AIDS, smoking, use of steroids, moist body parts, and other immunocompromised conditions. Mobility increases the dissemination of anthropophilic dermatophytes to previously poorly affected geographical areas (Hayette and Sacheli, 2015).

.

Table 1: Epidemiology of main species of dermatophytes and their associated clinical presentations (Nennoff *et al.*,2014)

Species (former taxonomy)	Ecological niche (preferred host)	Clinical picture in human	Epidemiology
Epidermophyton floccosum	Anthropophilic (human)	Tinea pedis, Tinea unguium, Tinea cruris.	World wide
Microsporum audouinii	Anthropophilic (human)	Tinea capitis, Tinea corporis.	Mainly found in sub-Saharan Africa
Microsporum canis	Zoophilic (cat, dog)	Tinea capitis, Tinea corporis.	West Africa
Nannizia fulva (*Microsporum gypseum*)	Geophilic (soil)	Tinea capitis (rarely)	Most common geophilic species

Table 2: Prevalence of tinea capitis among school children in sub-Saharan Africa.

Prevalence (%)	Country	Year of Publication	Reference
76.1	Nigeria	2011	Adefemi *et al.*
68.0	Kenya	2015	Moto *et al.*
49.5	Rwanda	1983	Buginco *et al.*
45.0	Nigeria	2016	Dogo *et al.*
44.8	Senegal	2016	Diongue *et al.*
39.3	Mali	2016	Coulibaly *et al.*
36.5	Ethiopia	2015	Leiva-Salinas *et al.*
35.2	Nigeria	2015	Kalu *et al.*
33.3	Kenya	2001	Ayaya *et al.*
31.2	Nigeria	2008	Ayanbimpe *et al.*
26.9	Nigeria	2014	Oke *et al.*
23.1	Gabon	2011	Hogewoning *et al.*
23.1	Gabon	2013	Hogewoning *et al.*
22.5	Tanzania	1998	Frederick *et al.*
20.6	Kenya	2013	Hogewoning *et al.*
15.4	Nigeria	2014	Ayanlowo *et al.*

Clinical Presentations of Tinea Tinea capitis:

This is a fungal infection of the scalp (ringworm of the scalp or herpes tonsurans) caused by *Microsporum*, *Epidermophyton* and *Trichophyton* spp. These organisms get attached to the sub-stratum corneum of the scalp and deposit their spores outside or inside the hair shafts which may result in an inflammatory or non-inflammatory infection respectively (Sajjan and Mangalgi, 2016). Inflammatory tinea capitis known as keroin is marked by painful pus-filled nodules and scarring alopecia, in which the affected area loses hair and leaves a scar. It is most common in children aged 3 to 14, but it can affect people of any age, particularly those who are immunocompromised, such as diabetics or cancer patients (Al Aboud and Crane, 2022).

Tinea capitis is the second most important clinical type of tinea seen among people with a previous family history of the disease, since the disease may be transmitted through fomites such as combs, hairbrushes, bedding, pillows, clothes, towels or furniture, amongst others (Seema *et al.* ,2011).

Figure1: Clinical presentation of tinea capitis (Lorio *et al.*,2015)
At the right, note the circular, grey and dot-like lesions associated with acute tinea capitis; at the left, note the wet purulent inflamed nodules (keroin) which is a characteristic of chronic tinea capitis.

Tinea corporis: This is a ringworm of glabrous skin characterised by a pink-reddish round-shaped patch with plaques and a raised scaly border that extends on the periphery and clears at the centre. It is commonly caused by fungi of the genera *Microsporum* and *Trichophyton*. *Trichophyton rubrum* has been reported to be the predominant species infecting people with a previous family history of the disease. Tinea corporis may be transmitted by direct contact with other infected individuals. In addition, the disease can be attributed to poor personal hygiene and strenuous work (Reddy, 2017). The itchy, scaly raised and red circular rough lesions on the arms, legs and trunks are well marginated with raised erythematous borders but may coalesce to form confluent areas of dry, scaling skin, inducing itching and scratching which in severe cases may ulcerate (Cerqueira *et al*., 2005; Corting, 2009).

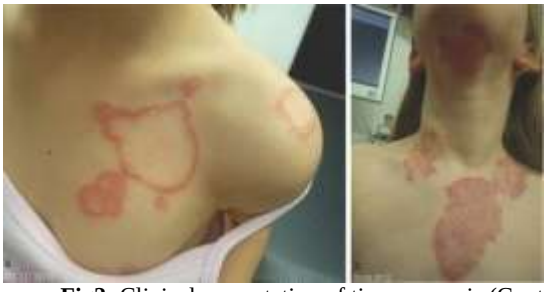

Fig2: Clinical presentation of tinea corporis (Gupta *et al*., 2017)
At the left, note the red colour lesions with central clearing on the chest;
At the right, note the red inflamed lesions, referred to as plaques.

Tinea pedis or Athlete's foot

It is the ringworm of feet involving interdigital webs and soles. The most common clinical finding is an intertriginous form associated with maceration, scaling, fissuring, and erythema which presents with itching and burning sensation. The most common causative agents are *E. floccosum, T. rubrum* and *T. mentagrophytes*. It is common among athletes and office workers, due to the constant wearing of shoes with synthetic nylon socks that do not absorb sweat (Achaurasiya, 2020). Tinea pedis causes moderate pruritus, characterized by the formation of rhagades over time which leads to burning sensations and pain. Secondary infections with Gram-positive (*Staphylococcus aureus*, Streptococci) and Gram-negative (*Escherichia coli*, *Klebsiella* spp., *Pseudomonas aeruginosa and Proteus* spp.) bacteria result in maceration and fetor at the edges and back of the feet (Hussein *et al*., 2015).

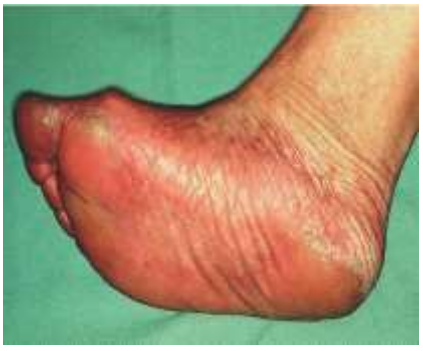

Figure 3*:* Moccasin-type tinea pedis *caused by Trichophyton rubrum* (Burzykowski *et al*., 2003; Muhannad *et al.*, 2004).
This is the most severe variant of tinea pedis which presents with dry, erythematous, scaly lesions with prominent borders

Tinea cruris/Jockitch/Dhobie'sitch

It is a ringworm involving the groin, and perineal areas often involving the upper thigh. Common species of

dermatophytes involved are *T. rubrum, T. mentagrophytes* and *E. floccosum.* It is mainly seen among students as they mostly wear synthetic tight undergarments in which sweat does not get absorbed and long-standing moisture predisposes to fungal infection.

Tinea unguium or onychomycosis*:*

This is ringworm infection of the nail plate, involving the nail plate which becomes brittle, brown, black, friable, thickened, and may crack because of piling up of subungual debris (Robert *et al*., 2017). The commonest species responsible for onychomycosis are (*T. rubrum, T.mentagrophytes* and *E. floccosum*). It is common among women due to the practice of cleaning the cowshed bare-handed, washing the household utensils with ash, and frequent dipping of hands in soap water; all of which enhance the chances of fungal infection, unlike men who mainly engage in white-collar jobs (Sofia *et al.*, 2000).

Fig 4: Clinical presentation of Tinea unguinnum (Christen *et al.*, 2017).
Note the white scaly lesions and desquamated brown and white nail beds

Diagnosis of Dermatophytosis-Procedures and common diagnostic techniques employed in the detection of dermatophytes include the following:

Sample collection

Collection of active border areas of lesions (into a sterile plate) involves the use of a sterile toothbrush and swab stick (India Mart, India), after disinfecting with 70% alcohol (Finelib, Lagos).

Direct Microscopic Examination

This entails an examination of samples after 5 minutes for hyphae and arthrospores on a slide containing 2 drops of 20% potassium hydroxide (Hardy Diagnostic, USA) using X10, x20 and x40 objective after placing the sample on a slide and making a homogenous mixture of the sample and KOH (Cobo *et al*., 2010).

Isolation of Fungi

This involves inoculating scraping in Sabouraud dextrose agar (SGA, Merck, Darmstadt, Germany) (32.5g/500ml) containing chloramphenicol (3.025g/500ml) (Axometry company, USA) and cycloheximide (Oxoid, UK) (1.25g/500ml), to inhibit the growth of bacteria and saprobic fungi respectively (Margill *et al*., 2007). The plates are to be incubated at 28°C for one to two weeks and examined at three days intervals for fungal growth. The scraping will also be inoculated into dermatophyte test medium (DTM), which is a constituent of soy peptone-0.01g/l, cycloheximide-0.002g/l (Oxoid, USA), chloramphenicol-0.05g/l (Thermofisher scientific USA), phenol red- 0.2gm/l (Suvchem laboratories, India) gentamicin sulphate-0.1gm/l, and agar-20g/l at 28°C for one to two weeks (Cheryl Grrenacre, 2017), The macroscopic examination of dermatophytes is based on the duration of growth, surface morphology, texture and change in colony pigmentation on both front and reverse side of the plate (Ellis *et al.*, 2007).

Indirect Microscopic Examination-

The second step taken to characterize dermatophyte will be based on a microscopic examination of the pure culture by staining the culture on a slide with lactophenol cotton blue, to observe the different shapes and structures of fungal sexual spores, also known as microconidia and macroconidia (LCB, Fluka, France) (Senanayake *et al.*, 2020).

Biochemical Characterisation Rice grain test

Dermatophytes are evaluated for growth on cooked sterile rice grain in slants, at an incubation temperature of 30°Cfor
5 days to assess the ability to utilize the vitamin content of rice (Ayanbimpe *et al*., 2008). *Microsporum audounni* grows poorly on cooked rice, unlike other species.

Invitro Hair Perforation Test

Short strands of hair are evaluated microscopically for hair perforation by inoculating isolates of dermatophytes in Petri dishes containing 25 ml of sterile distilled water (Belinda water, Lagos), three drops of 10% yeast extract and sterile hair. Zoophilic dermatophytes such as *Microsporum canis*, and *Trichophyton verrucosum* and anthropophilic dermatophytes such as *Epidermophyton flocossum* and some strains of *Microsporum audounni* invade and perforate hair

Strands result in the deposition of spores within the hair and are therefore hair perforation-positive (Davide *et al.*,2011).

Sodium Chloride (NaCl) Tolerance Test

Sabouraud dextrose agar supplemented with 3% NaCl is used to detect species salt tolerance and macroconidia formation, after incubation at 25°C for 3 days (Enany *et al*., 2013).

Urea Utilization Test

Assessment of growth on Christensen's urea medium (Oxoid, UK), after incubation at 28^{o}c for five days, demonstrates the utilization of urea by dermatophytes and its enzymatic (urease) breakdown to carbon dioxide and ammonia, accompanied by a change in colour of phenol red which is a constituent of the urea medium from straw yellow to pink as a result of the ammonia released (Fatima *et al.*, 2017). All species of dermatophytes are urea positive in varying degrees except *T. rubrum* which is urea negative.

Casein Hydrolysis Test

Dermatophytes hydrolyse casein in casein dextrose yeast extract agar (Merck, Germany), after incubation at 25°Cfor 3 to 5 days. Hydrolysis of casein is a result of the enzymatic breakdown of casein agar by caseinase enzyme into amino acids, dipeptides and polypeptides produced by dermatophytes, accompanied by a consequential clearing around the growth zone (Sagar, 2021).

Anti-fungal Drugs for Dermatophytes

Recognition and appropriate treatment of dermatophytosis reduce both morbidity and discomfort and lessen the possibility of transmission as well (Molina, 2011). To determine the best treatment approach, the physician must consider several factors such as safety, efficacy, cost of treatment options and the likelihood that the patient will comply with treatment. Oral therapy such as Griseofulvin (Fulvicin), Itraconazole (Sporanox), Terbinafine (Lamisil), Eficonazole, Amorolfin, Voriconazole and Fluconazole, in addition to topical agents such as 2% Ketoconazole are effective in the treatment of dermatophytosis (Roberts and Friedlander, 2005).

Absorption properties of oral antifungal agents vary; therefore, for optimal drug absorption, Itraconazole and ketoconazole should be taken with an acidic food, such, as cola beverage, while Griseofulvin should be taken with a fatty meal (Bennet *et al*., 2000). Ultra micro size griseofulvin decreases the need to be taken with food, thereby achieving the best drug absorption; therefore, patients being treated with these antifungal agents should avoid taking antacids, proton pump inhibitors and histamine H_2- receptor blockers (Chan and Friedlander, 2004). In a meta-analysis study, Terbinafine treatment of four weeks was as effective in treating *Trichophyton* spp, as 8 weeks of Griseofulvin treatment (Fleece *et al*., 2004). When compared to other treatments Griseofulvin and Terbinafine are equally effective, but Griseofulvin is most effective against *Microsporum* infections, while Terbinafine is most effective against *Trichophyton* infections (Fuller *et al*.,2001). Griseofulvin is a mitotic inhibitor that interferes with nucleic acid, protein, and cell wall synthesis of replicating dermatophyte cells, while Terbinafine is an

allyl-amine whose antifungal effect is due to inhibition of squalene epoxidase (Abdel-Rahman *et al*., 2005).

Prevention and Control of Dermatophytosis

The antifungal susceptibility profile will lead to the establishment of the most effective antifungal agent, which can be used to curb the infection; additionally, the establishment of a reference antifungal susceptibility testing method may allow the clinician to select the appropriate therapy for the treatment of infections caused by dermatophytes (Jessup *et al.* 2000). The early identification of the causative agent of tinea is a prerequisite for the identification of probable source, the effective management of the disease, and the prevention of spreading.

The establishment of a reference anti-fungal susceptibility testing method may allow the clinician to select the appropriate therapy for the treatment of infections caused by dermatophytes. The characterization of resistant genes remains a powerful guide for understanding clinically significant resistant mechanisms. Advances in the molecular diagnosis of dermatophytosis have improved the speed, specificities, and sensitivities. Methods such as gene-specific PCR (Zhu *et al*., 2020), Southern blotting (Green and Sambrook, 2021), sequencing, (Li *et al.*, 2008) and real-time PCR(Ohst*etal*.,2016) are therefore promising techniques for providing an accurate diagnosis of dermatophytes (Ninnet *et al*., 2008). There is a need for proper infection control measures and strict health policies within the country. Emphasis should be laid on good personal hygiene practices such as avoiding contact with lesions on the skin and nails of infected people and wearing loose-fitting clothing on the affected areas to reduce the risk of contracting dermatophytosis (Marina *et al.*, 2006). The establishment of a new health policy will keep the promise of meeting the millennium development goals of universal access to primary education, thereby reducing child mortality arising from tinea (Lwazi and Joyce, 2020).

Patient Management

Household members who may be carriers should be treated with selenium sulfide or ketoconazole shampoo (Chen *et al*., 2005). Household items such as brushes and combs should be replaced and then boiled for 5 minutes once a week while the patient is in therapy to prevent reinfection. If a household pet is suspected of infection, the pet should be treated (Rosanna, 2014). Many patients develop a rash after starting griseofulvin; this intra-dermal (ID) reaction should be explained to patients so that they do not stop therapy because of a presumed drug reaction.

Conclusion

Every patient with tinea infection should be properly examined mycologically and treated accordingly. Different body locations are associated with diverse types of tinea characterized by significant observable features. Specific mycological equipment is employed in the collection of different samples from different body locations. Dermatophyte test media is a more useful diagnostic identification medium in the isolation of dermatophytes. A comprehensive mycology analysis involving, microscopy, culture, biochemical identification and molecular

techniques are required to completely ascertain the causative agent of dermatophytosis. Terbinafin has been regarded as the gold standard for the treatment of dermatophytosis and a need to routinely incorporate this antifungal in the treatment of dermatophytosis is essential. Simple achievable interventions like good hygiene practices and encouraging people to demonstrate good hygiene will go a long way to reduce the risk of contracting dermatophytosis which is the commonest fungal infection, especially in humid areas like Nigeria and India where it is densely distributed.

Conflict of Interest: There is no conflict of interest to be declared.

Authors' contributions: All authors contributed to this article. All authors read and approved the final manuscript.

References

Abdel-Rahman, S.M., Herron, J., Fallon-Friedlander, S., Hauffe, S., Horowitz, A. and Riviere, G. J. (2005). Pharmacokinetics of Terbinafine in young children treated for tinea capitis. *Pediatric Infectious Disease Journal*. 24 (10):886-891.

Achaurasiya (2020). Epidemiology: General characteristics, pathogenesis, clinical findings, laboratory diagnosis, treatment, prevention and control. *Universe 84a*.

Achterman, R.R. and White, T.C. (2012). Dermatophyte virulence factors: Identifying and analyzing genes that may contribute to chronic or acute skin infections. *International Journal of Microbiology*. Press Private Limited; pp.604– 607.

Adefemi, S.A., Odeigah, L.O. and Alabi, K.M. (2011). Prevalence of dermatophytosis among primary school children in Oke-oyi community of Kwara state. *Nigerian Journal of Clinical Practice.* 14:23-28.

AlAboud, A.M (2022). Crane J.S. In: StatePearls.Treasure Island: StatPearls publishing.

Alshawa, K., Beretti, J.L., Lacroix, C., Feuilhade, M., Dauphin, B., Quesne, G. *et al*. (2012) Successful identification of clinical dermatophytes and Neoscytalidium species by matrix-assisted laser desorption ionization-time of flight mass spectrometry. *Journal of Clinical Microbiology*. 50(7):2277–81.

Ayanbimpe, G.M., Enweani, I. and Solomon, E.G. (2003). Fungal infections in Jos: a-9 year study. *African Journal of Clinical Microbiology*. 4:2-10.

Bennett, M.L., Fleischer, A.B. and Loveless, J.W and Feldman, S.R. (2000). Oral griseofulvin remains the treatment of choice for tinea capitis in children. *Pediatric Dermatology Journal*. 17:304– 309.

Burzykowski, T., Molenberghs, G., Abeck, D., Haneke, E., Hay,R.and Katsambas A.(2003).High prevalence of foot diseases in Europe: results of the Achilles Project.*Mycoses*46(11–12):496– 505.

Cerqueira, M.D.P., Neves, R.P.,Magalhães, O.M.C., Souza-Motta, C.M. and Queiroz, L.A. (2005). Pathogenic aspects of *Epidermophyton floccosum* langeron et milochevitch as possible etiological agent of tinea capitis. *Brazilian Journal of Microbiology*. 36:3637.

Chen, C., William, J.V.and Hubbard, T.W. (2005). Selenium sulfide, ketoconazole and ciclopirox shampoo as additional treatments for tinea capitis (Scalp Ringworm). *Clinical Trials.gov* NCT00127868.

Chepchirchir, A., Bii, C. and Ndinya-Achola, J.O (2009). Dermatophyte infections in primary school children in Kibera slums of Nairobi. *East African Medical Journal*. 86: 59–68.

Cheryl, G. (2017). Small Animal Dermatology. 4thedition; 30-44.

Cobo, E.C., Silva, J.C., Cota, U.A., Machado, J.R. and Castellano, L.R. (2010). Evaluation of a modified microscopic direct diagnosis of dermatophytosis. *Journal of Microbiological Methods*.81:205-207.

Corting, C.H. (2009). Fungal infections. In: Braun-Falco, O., Burgdorf, W.H.C., Plewig, G., Wolf H.H. and Landthaler, M.3rd edition; Springer Verlag, Italy.p.205-239.

Davide,D., Valerie, H. and Philipp, P.B.(2011). *Microsporum audouinii* tinea capitis in a Swiss School: assessment and management of patients and asymptomatic carriers. *Medical Mycology*. 49: 324-328.

Deacon. (2006).Fungal Biology. Blackwell Publishing, Ltd..

DeHoog, K., Dukik, M., Monod, A., Packeu, D., Stubbe, M., Hendrickx, C., Kupsch, B. and Stielow, J. (2017). Toward a novel multilocus phylogenetic taxonomy for the *dermatophytes. Mycopathologia* **182**: 5-31.

Ellis, D., Davis S., Alexiou, H., Handke, R. and Bartley, R. (2007). Descriptions of medical fungi,2ndedition p.61-167.

Enany, M.E., khafagy, A.R., Madiha, S.I., Marwa, M.A. and Dalia, T.H. (2013). Identification of dermatophytes isolated from ringworm lesions of camels.*Suez Canal Veterinary Medicin eJournal.* 18(1):1-2.

Enweani, I.B., Ozan, C.C., Agbonlahor, E.E.and Ndip R.N. (1996). Dermatophytosis in schoolchildren in Ekpoma, Nigeria. *Mycoses*. 39:303-305.

Fatima, A., Abed, A., Jawadk, A. (2017). Phenotypic and molecular identification of *Trichophyton* rubrum and *Microsporum gypseum* of dermatophytes. *Journal of Global Pharma Technology*.2017;10 (9)103-111

Fleece, D., Gaughan, J.P. and Aronoff, S.C. (2004). Griseofulvin versus terbinafine in the treatment of tinea capitis: a meta-analysis of randomized, clinical trials. *Pediatric Dermatology Journal*.114(5): 1312-1315.

Fuller, L.C., Smith, C.H., Cerio, R., Marsden, R.A., Midgley, G. and Beard, A.L. (2013). A randomized comparison of 4 weeks of terbinafine vs. 8 weeks of

griseofulvin for the treatment of tinea capitis. *British Journal of Dermatology*.144: 321.

Green, M. R. and Sambrook, J. (2021). Southern blotting. *Cold Spring Harbor Protocols*, (7), pdb- prot100487.

Grumbt, M., Monod, T., Yamada, C., Hertweck, J.and Kunert, P.S. (2013). Keratin degradation by dermatophytes relies on cysteine dioxygenase and a sulfite efflux pump. *Journal of Investigation Dermatology*.133(6): 1550.

Gupta, A.K., Foley, K.A. and Versteeg, S.G. (2017). New antifungal agents and new formulations against dermatophytes. *Mycopathologia* 182(1–2):127–141.

Havlickova, B., Czaika, V.A, and Friedrich, M. (2008). Epidemiological trends in skin mycoses worldwide. *Mycoses*. 51(4):2–15.

Hay, R.J. (2015). Dermatophytosis (ringworm) and other superficial mycoses. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases.8thed. Philadelphia, PA. Elsevier, 2985–2994.

Hayette, M.R. (2015) Sacheli. *Current Fungal Infection* (9):164.

Hussein, M.H.E, Yasser, F.M and Hamed, M.A. (2015). Study of the aetiological causes of toe web space lesions in Cairo Egypt. *Dermatology Research and Practice*. 10: 1-7.

Jessup, C.J, Warner, J. and Ghannoum, M.A. (2000). (2 Antifungal susceptibility testing of dermatophytes: Establishing a medium for inducing conidial growth and evaluation of susceptibility of clinical isolates. *Journal of Clinical Microbiology*. 38(1): 341-344.

Jun, Y.C., Larissa, M.P. and William, R.R. (2014). Drug strategies targeting CYP51 in Neglected Tropical Diseases. *Chemical Reviews*.114(22):11242- 11271.

Kanbe, T., Suzuki, Y. and Kamiya, A. (2013). PCR-based identification of common dermatophyte species using primer sets specific for the DNA topoisomerase II genes. *Journal of DermatologicalScience*.32: 151–161.

Kappe, R., Okeke, C.N, Fauser, C *et al*. (2013). Molecular probes for the detection of pathogenic fungi in the presence of human tissue. *Journal of Medical Microbiology*. 47:811–820.

Lwazi, S. and Joyce, M. (2020). Modelling positive behaviour: A vital strategy in instilling positive discipline among secondary school learners. *Randwick International Social Science Journal*. 1(2):308-323.

Liu, D., Coloe, S., Baird, R. and Pedersen, J. (2000). Application of PCR to the identification of dermatophyte fungi. *Journal of Medical Microbiology*. 49:493-7.

Madhu, R. (2017). The great Indian epidemic of superficial dermatophytosis: an appraisal. *Indian Journal of Dermatology* 62(3):227.

Marina, C., Janio, S., Aytron, S.C. and Ana Aurea, B. (2013). Dermatophytes isolated from dogs and cats suspected of dermatophytosis in Southern Brazil. *Acta ScientiaeVeterinariae*.34(2):119-124.

Molina, D.A. (2011). Clinical, diagnostic and therapeutic aspects of dermatophytosis. *Enfermedades infecciosasy microbiologia clinica*. 29(3):33-39.

Morar, D., lova, N.C. and Gupta, A.K. (2004). Tinea capitis in Kwa-Zulu Natal, South Africa. *Pediatric Dermatology*. 21:444–447. Muhannad, A.H., Steven, M.F., Mahnaz, S. and Guha, K. (2004). Dermatology for the practicing allergist: Tinea pedis and its complications. *Clinical and Molecular Allergy*. 2(1):5.

Nenoff, P., Krüger, C., Ginter-Hanselmayer, G., Schulte- Beerbühl R. and Tietz, H. (2014). *Journal of German Sociology and Dermatology*. 12, 188.

Ninet, B., Jan, I. and Bontems, O. (2008). Identification of dermatophyte species by 28Sribosomal DNA sequencing with a commercial kit. *Journal of Clinical Microbiology*. 41: 826–83023.

Ohst K., C. and Gräser, Y. (2016). Detection of common dermatophytes in clinical specimens using a simple quantitative real-time polymerase chain reaction assay. *Brazillian Journal of Dermatology*.174: 602–609.

Rosanna, M. (2014). In Equine Infectious Diseases (second edition) 2014.

Ohst Kupsch, C. and Gräser, Y. (2016). Detection of common dermatophytes in clinical specimens using a simple quantitative real-time TaqMan polymerase chain reaction assay. *Brazillian Journal of Dermatology*.174: 602–609.

Patel, G.A. and Schwartz, R.A. (2017). Tinea capitis: still An unsolved problem? *Mycoses* 54(3):183-187.

Reddy, K.R. (2017). Fungal Infections (mycoses): Dermatophytoses (Tinea, Ringworm). Journal of Gandaki Medical College-Nepal. 10 (1): 1-13.

Roberts, B. and Friedlander, S.(2005). Tinea capitis a treatment update. Pediatric Annals. 34: 191-200.

Robert, B., Smail, H.R. and Robert, S. (2017). Pediatric nail disorders, CRC Press, Raton Boca London New York. 13:1-324.

Sagar, A. (2021). Casein hydrolysis Test- Objectives, Principle, Media, Procedure, Results. Microbe Notes.

Sajjan, A.G. and Mangalgi, S.S. (2016). Clinicomycological profile of tinea capitis in children residing in orphanages. International

Journal of Biological and Medical Research.3(4): 2405-2407.

Saunte, D.M.L., Hare, R.K., Jørgensen, K.M., Jørgensen, R., Deleuran, M., Zachariae, C.O., et al. (2019). Emerging terbinafine resistance in Trichophyton: Clinical characteristics, squalene epoxidase gene mutations, and are liable EUCAST method for detection. Antimicrobial Agents Chemotherapy. 63(10):1–9.

Seebacher, C., Bouchara, J.P. and Mignon, B. (2008). Updates on the epidemiology of dermatophyte infections. Mycopathologia. 166:335-52.

Seema, B., kulkarni, S. and Irfaanakhter. (2011). The incidence of tinea capitis in a tertiary care rural hospital. Journal of Clinical and Diagnostic Research 5:307-311.

Senanayake, I.C., Rathnyaka, A.R., Marasinghe, D.S., Calabon, M.S., Gentekaki, E., Lee, H.B., Hurdeal, V.G. and Pem, D. (2020). Morphological approaches in study in g fungi collection, examination, isolation, sporulation and preservation. Mycosphere.11(1):2678-2754.