

Full Length Research Paper

Tungiasis: An overview

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Tungiasis exists worldwide with varying degrees of incidence and prevalence. The aim of this paper is to review the existing literature on Tungiasis which has been shown to be a public health concern for resource-poor rural communities in developing countries such as Nigeria, Kenya, Cameroon, Trinidad, Tobago and Brazil, where its prevalence has been known to reach 50%. Reviewed literature showed that poor hygienic conditions, increased poverty levels, prolonged dry season and fear of stigmatization are among the most important risk factors, severely influencing the persistence of the tungiasis. The presence of the jigger in the skin causes itching sensation, and in severe cases causes loss of nails, formation of ulcers, inflammation, suppuration, chronic lymphedema, sepsis and even death. Jigger infestation affects the education of children as they might be unable to walk to school, write properly, or participate in regular learning activities. Tungiasis is likely to increase and cause livelihood of communities in developing countries. Thus, new prevention and control approaches should be designed through multi-interdisciplinary team to mitigate the persistence of the disease, particularly in vulnerable communities.

Key words: Jiggers fleas, poverty, risk factors, school children.

INTRODUCTION

Tungiasis is a parasitic disease of humans and animals caused by fleas (Siphonaptera) belonging to the genus *Tunga*. Two species, *Tunga penetrans* and *Tunga trimamillata*, out of 10 described to date, are known to affect man or domestic animals; the other eight are exclusive to a few species of wild mammals. *T. penetrans* and *T. trimamillata* originated from Latin America, although the first species is also found in sub-Saharan Africa (between 20°N and 25°S) (Pampiglione et al., 2009). In addition, Tungiasis is endemic in equatorial and

subtropical regions and rarely described in European countries, where clinicians and general pathologists could not be aware of this parasitic disease (Palicelli et al., 2016). The disease caused by this parasite causes debility in resource-poor communities of developing countries (Wilcke et al., 2002; Muehlen et al., 2006; Collins et al., 2009).

The first case of Tungiasis was described in 1526 by Gonzalo Fernández, where he discussed the skin infection and its symptoms on crew members from

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Columbus's Santa Maria after they were shipwrecked in Haiti. Through ship routes and further expeditions, the chigoe flea was spread to the rest of the world, particularly to the rest of Latin America and Africa. The spread to greater Africa occurred throughout the 17th and 19th centuries, specifically in 1872 when the infected crewmen of the ship Thomas Mitchell introduced it into Angola by illegal dumping of sand ballast, having sailed from Brazil (Jeffreys, 1952; http://en.wikipedia.org/wiki/Gonzalo_Fern%C3%A1ndez_de_Oviedo_y_Vald%C3%A9s).

Jiggers are easily transmitted among the poor living in urban slums and rural societies (Heukelbach et al., 2005; Joseph et al., 2006; Winter et al., 2009). It is endemic in developing countries in the tropics, mainly in the resource poor people of South America, the Caribbean and sub-Saharan Africa (Heukelbach et al., 2001). The disease only periodically affects travelers to endemic regions in South America and Africa; however persons living in native communities commonly suffer from serious infestation (Franck et al., 2003; Heukelbach, 2005).

In tropical regions, tungiasis caused by *T. penetrans* is a human disease directly linked to the parasitism of humans by fleas. Though, to many of the general population, the insidious attacks by fleas on people and domestic animals causes irritation, blood loss, and severe discomfort are equally important as disease threat (Bitam et al., 2010). The aim of this paper was to review the existing literature concerning tungiasis.

MATERIALS AND METHODS

An electronic internet search was carried out via PubMed and google scholars. Terminologies used to search and access the required data included tungiasis, *T. penetrans*, Jigger fleas, sand flea, pulex irritant and prevalence of tungiasis. Inclusion criteria were books and book chapters, short communication reports, case reports, conference abstracts, recognized international organizations reports, country reports and articles. The data/documents distributed by unrecognized and/or unknown publisher were not included. Finally, all relevant literatures related to tungiasis were reviewed properly for this study.

RESULTS AND DISCUSION

Ecological distribution

According to the review of Heukelbach et al. (2001), tungiasis is endemic in Latin America, the Caribbean and sub-Saharan Africa. Sporadic occurrence has been reported in parts of Asia and Oceania. In Latin America, it is found in regions spanning to Mexico to Northern Argentina and Chile. In Africa, the ecto-parasite is found in the whole sub-Saharan region: from Sierra Leone, Ivory Coast, Nigeria and Ethiopia to South Africa; it also occurs in Zanzibar and Madagascar. Tourism in endemic regions and globalization may result in new cases in developed countries and previously unaffected regions

(Palicelli et al., 2016).

Transmission

It is identified that the animal reservoir plays vital role for spread dynamics in endemic populations. In specific, dogs, cats and rats have been described to be commonly infested, and several authors reported severe disease in pigs from various African countries (Ugbomoiko et al., 2007). When humans live in near interaction with infected animals, the risk of infestation is great and the extent of infestation is likewise great. These animals continue transmitting *T. penetrans* and contribute to unending spread in the society as long as they get in contact with human (Pilger et al., 2008).

Life cycle

Eggs are shed by the gravid female into the environment. Eggs hatch into larvae in about 3-4 days and feed on organic debris in the environment. *T. penetrans* has two larval stages before forming pupae. The pupae are in cocoons that are often covered with debris from the environment (sand, pebbles, etc). The larval and pupal stages take about 3-4 weeks to complete. Afterwards, adults hatch from pupae and seek out a warm-blooded host for blood meals. Both males and females feed intermittently on their host, but only mated females burrow into the skin (epidermis) of the host, where they cause a nodular swelling. Females do not have any specialized burrowing organs, and simply claw into the epidermis after attaching with their mouthparts. After penetrating the stratum corneum, they burrow into the stratum granulosum, with only their posterior ends exposed to the environment. The female fleas continue to feed and their abdomens extend up to about 1 cm. Females shed about 100 eggs over a two-week period, after which they die and are sloughed by the host's skin (CDC, 2016) (Figure 1).

The male flea dies after copulation. The female flea continues *in vivo* ecto development. Once the female flea expels 100-200 eggs, the cycle of transmission begins again (Heukelbach et al., 2005; Nagy et al., 2007).

Collins et al. (2009) documented that the natural history of clinical human tungiasis develops in five phases. Phase I starts with penetration of the adult flea into the skin, leading to a rigorous swelling and dilation of blood vessels in the dermis. In phase II, the flea thrusts its head into the superficial layers of the dermis, suckling on blood vessels. The posterior part of the flea relics on the skin surface, and continue having contact with the outer part. This delivers air for breathing and a way for both evacuations and eggs. During phase III, the parasite produces up to 200 white ovoid eggs, causing her body to swell up to 7 mm. The insect can now be seen as a yellow-whitish lesion under a hard hyperkeratotic skin.

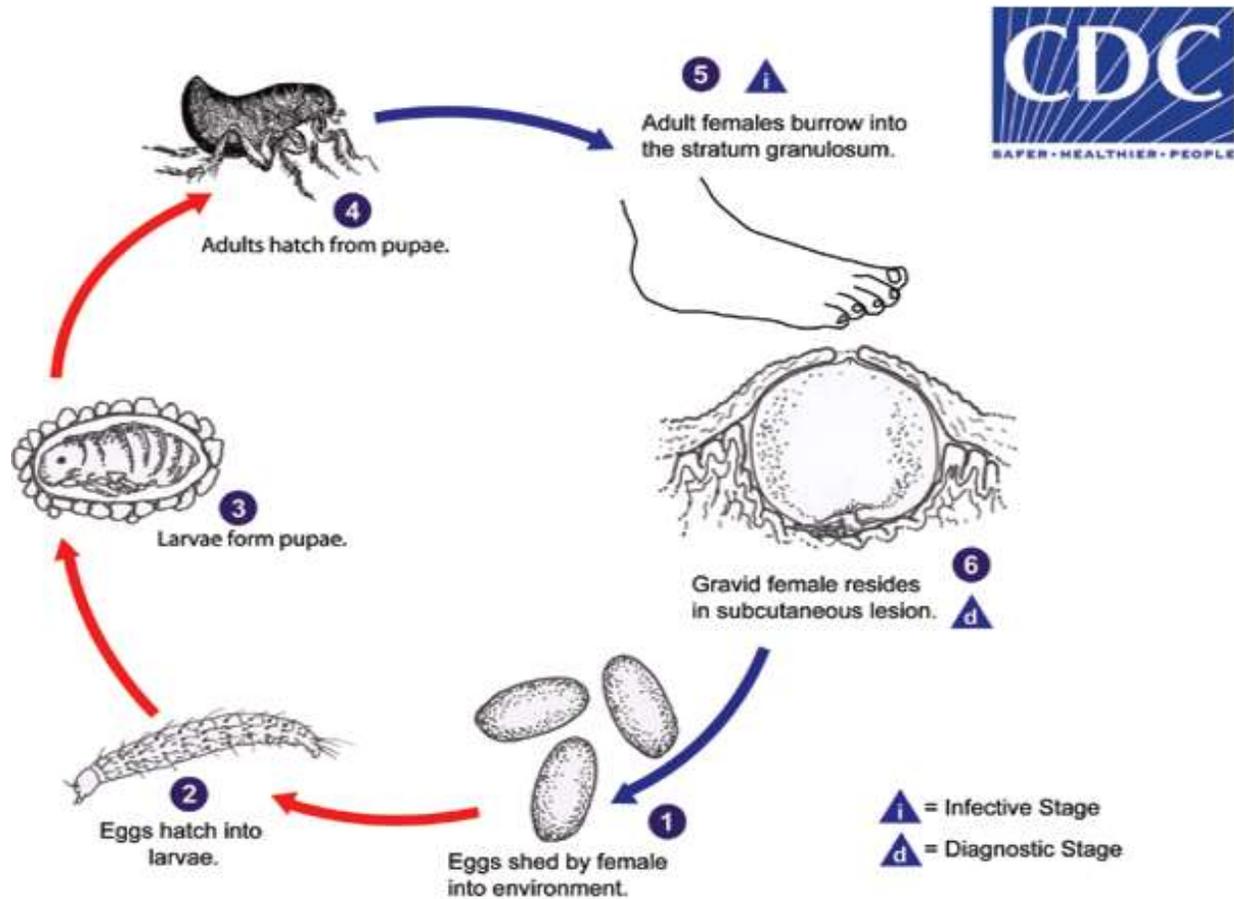


Figure 1. life cycle of jigger fleas. Source: CDC, 2016; www.cdc.gov/parasites/.

Phase IV starts after deposition of the eggs. The female flea dies and the carcass is ejected. During phase V, reorganization of the epidermis occurs, taking about four weeks, leaving slight residues that will stay for months. Meanwhile, the eggs that were left during phase III hatch in three to four days, liberating larvae that develop into pupae. After two weeks, the pupae develop adult fleas, finalizing the cycle (Heemskerk et al., 2005).

Clinical findings

The initial burrowing by the gravid females is usually painless; symptoms, including itching and irritation, usually start to develop as the females become fully-developed into the engorged state. Inflammation and ulceration may become severe, and multiple lesions in the feet can lead to difficulty in walking. Secondary bacterial infections, including tetanus and gangrene, are not uncommon with tungiasis (CDC, 2016).

The initial sign of infestation by jigger flea is a minute black lesion on the skin at the site of entrance. The zone around the entrenched flea develops very irritating

swelling leading to ulcerations, lymphangitis, and formation of pus. When the female fleas die, they rest embedded inside the host, repeatedly causing swelling and consequently secondary infections. If unnoticed, it leads to gangrene, auto-amputation of fingers, damage of toes, tetanus, or death (Mark, 2004; Kiprono et al., 2012).

Diagnosis

The diagnosis of tungiasis is usually made by visual/macroscopic examination, where the embedded gravid female abdomen can be appreciated as a white covering with a black point in its midpoint. Commonly, a limited eggs twig to the skin nearby the lesion, a finding that is pathognomonic for the infection (Bitam et al., 2010).

Differential diagnosis

The differential diagnosis of tungiasis consist of myiasis, verruca vulgaris, ingrown toe nail, acute paronychia, mycotic granuloma, malignant melanoma, and arthropod

bites (Muehlen et al., 2003; Bitam et al., 2010).

Epidemiology of the disease

Tungiasis is present globally in more than 88 countries with varying degrees of incidence and prevalence. Flea-borne infections are emerging or re-emerging throughout the world, and their incidence is on the rise (Bitam et al., 2010). This parasitic disease is of special community health concern in extremely prevalent regions such as Nigeria, Kenya, Cameroon, Trinidad, Tobago, and Brazil, where its prevalence, mostly in poor peoples, has been recognized to reach 50% (Heukelbach, 2005). *T. penetrans* is distributed in tropical and subtropical regions of the world, including Mexico to South America, the West Indies and Africa. The fleas normally occur in sandy climates, including beaches, stables and farms (CDC, 2016).

Risk factors

Poverty

Poverty is an underlying determinant for the jiggers' epidemic (Mørkve, 2013). Several studies reported that the occurrence of jigger is high among poor groups and that individuals suffering of jiggers are less economically productive (Heukelbach et al., 2001; Heukelbach et al., 2002). It is difficult for poor people to own cemented houses, shoes or sanitary effects: many of them have to walk barefoot, reside in houses with mud walls (and mud/soil floors), and share their living space with animals that could be infected by the flea (Muehlen et al., 2006; Kiprono et al., 2012).

Poor sanitation, poor infrastructure and animal reservoirs are central features for the high occurrence. Poor peoples are often found outside the largest cities, where there are more animals. Animals remain reservoirs of jiggers, and the extra infested animals in a community, the greater is the risk of infestation among people (Heukelbach et al., 2002). In addition to this, illiteracy, ignorance and neglect presumably are other factors favoring the high prevalence of severe pathology in children (Heukelbach et al., 2001).

Psychological suffering

A research has been done in Bungoma, Kenya concerning tungiasis by Mørkve, (2013). According to the report of this author, "those infected participants explained that they feared to be laughed at by neighbors, at the market, at school, or during jiggers' removal campaigns. However, the majority mentioned the fear of being ridiculed at the health facilities as their main concern. For instance, an elderly man claimed that; he did not want

to go to the health center because he was afraid of being stigmatized".

Seasonal variation

The past decades have seen a dramatic change in the geographic and host ranges of many vector-borne pathogens, and their diseases. This process is often driven by climate change and the destruction of wild habitats (Bernard et al., 2012). Seasonal variation may influence the occurrence of Jigger fleas. A study conducted in Brazil showed that the tungiasis has a significant seasonal difference, with the prevalence of 54.4 and 16.8% in dry and rainy period, correspondingly (Heukelbach, 2005).

Consequences of Tungiasis

Uncomfortability

The appearance of the jigger in the skin causes a severe irritating sense and discomfort (Mark, 2004). When the jigger is manually extracted, minor sores are left around the feet and since the victims walk barefoot, walking becomes an agonizing exercise. Grass and small sands get into the holes left by the removed fleas and induce painful pain (Kiprono et al., 2012; <http://www.AhadiKenyaTrust.org>). In addition, Bernard et al. (2012) conducted a questionnaire survey concerning tungiasis. In his finding, 59.8% study participant described that jigger infested persons feel uncomfortable and might be lazy (Figure 2).

Secondary complication

Severe complications due to tungiasis are common in areas where people suffer from persistent re-infestation, and where sanitation situations are unwarranted. Microbial superinfection is frequently present, and pustules, abscesses and ulcers are commonly realized (Feldmeier et al., 2002; Heukelbach et al., 2006). The wound is associated with illness such as loss of nails, formation of ulcers, swelling, suppuration, persistent lymphedema and sepsis. Microbial super infection can lead to tissue necrosis (Joseph et al., 2006; Feldmeier et al., 2006a). Secondary infections due to jiggers might cause auto-amputation of fingers and death (Kiprono et al., 2012). Most importantly, tetanus is among secondary complication that can lead to death (Feed the Children, 2007). Reports indicated that, in 2011 about 265 persons died because of jiggers-related causes in Kenya (Karuga, 2011; Mørkve, 2013).

Low educational activity

Jigger infestation affects the education of teenagers as



Figure 2. Victims of tungiasis.
Source: Morkve (2013).



Figure 3. Several lesions on the heel of a Brazilian girl.
Source: Ugbomoiko et al. (2007).

they may be incapable to walk to school, and join in regular learning activities (Kiprono et al., 2012). For instance, in Kenya reports shown that 50 000 school going children have dropped out of school due to severe infestation of tungiasis (Karuga, 2011; Mørkve, 2013; <http://www.AhadiKenyaTrust.org>).

Public/political rights offense

Reports indicated that, about 2,000,000 persons were estimated to be infected by Jiggers in Kenya and among these, 800,000 did not vote due to tungiasis in 2007 (available online at <http://www.AhadiKenyaTrust.org>).



Figure 4. Seriously ulcerated feet and deformed nails as a result of tungiasis. Source: Morkve (2013).

People suffering from this disease are incapable to take part entirely in the democratic practice to effect politics.

Lack of self-confidence

The parasite causes pain and injury that can seriously impede activities and performance of many of life's chores, making a person dependent on others. The ulcerations and auto amputation of the digits make the victims feel embarrassed of being in public places and may usually reduce their self-confidence (Kiprono et al., 2012) (Figure 4).

Treatment

The first line of therapy is the mechanical extraction of the flea from the infected host. Removal is not always easy and may be painful for the patient. It can be accomplished using a sterile needle after cleaning the area with an antiseptic solution (Bitam et al., 2010). If the flea bursts, severe inflammation is inevitable (Heukelbach et al., 2001).

Prevention and control

Prevention approaches include: wearing closed shoes; keeping animals contained; wetting the floors within

houses regularly; maintaining good personal hygiene (Collins et al., 2009). Daily check of the feet with immediate extraction of embedded fleas and subsequent disinfections of the lesion protect against complications (Heukelbach et al., 2001). Administering antibiotics and applying insecticide will minimize the occurrence and impact of *T. penetrans* and secondary microbial complications (Joseph et al., 2006; Pilger et al., 2008).

Conclusion

Tungiasis is existing globally with varying degrees of incidence and prevalence. The disease has been shown to be a public health concern for resource-poor rural people in developing countries in Nigeria, Kenya, Cameroon, Trinidad, Tobago, and Brazil, where its prevalence has been known to reach 50%. As a literature reviewed, poor sanitation, increased poverty levels, prolonged dry season and psychological suffering/stigmatization are among the most important risk factors, severely influencing the persistence of the tungiasis. The presence of the jigger in the skin causes itching feeling, and in severe cases causes damage of nails, formation of ulcers, inflammation, suppuration, chronic lymphedema, sepsis and could be death. Jigger infestation affects the education of teenagers as they might be incapable to walk to school, join in regular learning activities. The ulcerations of the fingers due to severe tungiasis make the sufferers feel ashamed of

being in social places and it usually reduces people's self-confidence. Jiggers infestation is likely to be increasing and causing livelihood of communities in developing countries. Therefore, new appropriate prevention and control approaches should be designed to mitigate the persistence of the disease (tungiasis), particularly in vulnerable and poor communities.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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