Review

Current status of tungiasis in endemic areas. Prevalence, risk factors, prevention

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Abstract: Tungiasis is a neglected parasitic skin disease caused by the permanent penetration of the female sand flea (Tunga penetrans) in the skin of the host, mainly the lower extremities.This gradually, it can lead to severe limb deformities.To date it is a health issue mainly in sub-Saharan Africa, the Caribbean, Latin and South America. It occurs mainly in poor rural populations and a major problem for children and the elderly. In diurnal zones, the incidence can reach over 73%. Over the past 20 years, studies in endemic areas on tungiasis have clarified to some extent the scientific community's knowledge for some problems of the disease. In this review, the current data on epidemiology, risk factors and prevention options are examinedof Tungiasis, as well as the expected steps of the international medical community to combat the disease.

Keywords: Tungiasis, Tunga penetrans, neglected tropical diseases, epidemiology

1. Introduction

Tungiasis is one of the neglected tropical parasitic skin diseases. It is caused by the invasion of the female sand flea Tunga penetrans into the skin, mainly on the soles of the lower limbs. Very rarely the infestation is caused by a related flea, Tunga trimamillata. To date it is a health issue mainly in sub-Saharan Africa, the Caribbean, Latin and South America. It occurs mainly in poor rural populations and is also a major problem for children. In diurnal zones, the incidence can reach over 73%. Early removal of the parasite from the skin is still the most common therapy. Tungiasis is one of the neglected tropical diseases (DNDi) already included in the World Health Organization's (WHO) DNDi Roadmap 2021-2030, and accordingly surveillance of its prevalence as well as comprehensive prevention measures should be increased [1]. Although prevalent in the endemic areas described, the disease occurs as isolated imported cases in a number of other countries. Its sidelining from major medical studies is probably due to the fact that it is prevalent mainly in poor, underdeveloped areas of the world and, although it results in severe lower limb deformities, it is rarely fatal.

2. Historical overview

The parasite Tunga penetrans was originally discovered in the Americas. The first empirical descriptions of the biology of the parasite and the changes it causes on the skin of affected patients were described as early as the 16th century by the German Hans Staden [2]. He observed Indian plmen in Brazil and skin changes in them caused by the so-called jigger flea, sand flea or chigo flea. These are several different names that would later be combined into the Latin name Tunga penetrans, a pathogenic skin parasite. The first scientific description was in the early 17th century by a Brazilian author who had long observed manifestations of the disease in indigenous tribes [3]. In the 19th century in South America, Africa and the Caribbean, inhabitants of entire settlements began to abandon their habitat and migrate. It appears that the cause was the infection with the jigger, which caused in some of them severe deformities of the lower limbs with ulcers, suppuration, even gangrenous areas [4,5] (Figure 1). Similar deformities in the lower limbs

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 17 November 2022 doi:10.20944/preprints202211.0340.v1

occurred in some soldiers in the colonial wars [6]. Contemporary authors describe a less dramatic picture, but the continued prevalence of Tunga penetrans in poor communities still threatens a number of individuals with the development of severe debilitation. Considering also the increased migration in the world, there is virtually no community that is not threatened by the occurrence of single cases, even in countries with high economic development and serious disinsection programs [7-9].3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Figure 1. Deformed limb from tungiasis (fotos from Michael Wunderli).

3. Biology of the parasite.

Tunga penetrans is extremely small in size, about 1 mm. Both female and male fleas feed on blood, but only females permanently penetrate the skin of their hosts, in some cases humans (Figure 2). During penetrance, complex biological changes occur in the flea - its abdomen hypertrophies, abdominal segments grow to about 1 cm, and multiple eggs develop within it. When the eggs are shed, involution of the parasite begins and it dies within a few weeks by detaching from the epidermis, but having omplished its main goal to lay its eggs in the host [4,10,11].

 doi:10.20944/preprints202211.0340.v1

Figure 2. Tunga penetrans, female (fotos from Michael Wunderli)

4. Epidemiology of tungiasis

In a systematic review and meta-analysis, the group of Obebe et al. established the prevalence and associated risk factors of tungiasis in sub-Saharan Africa (SSA), which is one of the endemic regions in the world [12]. Information on population-based studies was searched in AJOL, Google Scholar, Web of Science and PubMed. SSA data for the period January 1980 and July 2020 were evaluated. Of 27 studies with 16303 individuals, from seven countries in SSA, analyzed in full text, the overall prevalence of disease was 33.4% (95% CI: 27.6-39.8). Ethiopia had the highest prevalence at 46.5% and Uganda the lowest at 20.1%. Risks were associated with sex, age of participants, presence of ground floor (of soil), irregular use of shoes, contact with animals, residence in rural areas. The risk associated with sex varied in most studies and according to most authors the incidence was related to exposure and environmental factors rather than actually to sex [12,13]. The age-specific prevalence is classical, being highest in children (5-14 years) and adults ≥60 years. Children most often work on farms or play on them barefoot, and adults are more likely to overlook or under-see a flea bite because of poor eyesight and lack the ability to remove it from their skin in a timely manner as people of active age [5,12-14]. The authors report that the presence of tungiasis can lead to shame and stigma, especially in children, which can limit their attendance at school and socialization [12,14]. Respectively, prevention measures should also strongly depend on age groups.

The parasite lives 3-5 cm below the sand level as it prefers an oxygen-poor habitat. That is why living in huts with earth floor gives an easy opportunity for infestation. All studies in the field have shown that modification of flooring, usually with cement, severely limits disease incidence [4,12-15]. Some studies have shown that no viable forms of Tunga penetrans have been detected in outdoor soil samples, but instead, soil samples under beds and hammocks, as well as in indoor dog kennels, are rich in the parasite (65.0% v. 35.0%; P=0.02) [15]. Authors working on the problem describe any part of the body as a possibility of infestation with Tunga penetrans, but all are adamant that the feet are most commonly affected due to the fact that the flea hops poorly. Different localisations are possible more commonly in young children playing on the ground [12,16,17]. Heukelbach et al. described 1184 residents of a poor neighborhood in Brazil. They found that 33.6% (95% CI : 30.9-36.4) had tungiasis, with only 6% having lesions at sites other than the feet. The second most frequent location was the upper extremities, especially the elbows, hips and gluteal region [17].

In these areas, walking barefoot is more the norm, and on rare occasions flip-flops are worn. In both cases this has been described as a serious risk factor. Unfortunately wearing shoes in such areas, especially in the absence of such habits, is seen as a physical inconvenience. Children in poor communities consider them a valuable resource and if they own them use them for special occasions - going to school or church for example. Similar evidence is presented for children specifically in Madagascar [10,12,14,18]. Travelling foreigners in such areas mainly wear flip-flops feeling more comfortable in the local rural areas and this is what contributes to their contracting and later transmitting the disease to new communities. In visits to Brazil, Madagascar, Uganda, and Ethiopia between 2007 and 2018, GeoSentinel, as a major global network monitoring travel-related diseases, recorded 87 cases of tungiasis in tourists [19]. In an earlier study covering 1997-2013, 35 tourists from Brazil alone were diagnosed with tungiasis [20].

All authors working on the subject note that the presence of dogs, goats, pigs, cats, in or around the house is an important factor for the development of tungiasis. These animals are usually a serious reservoir for Tunga penetrans [6,8,21,22].

An indirect relationship between the incidence of tonsillitis and the type of water supply has also been demonstrated. A link has been made to both family hygiene and the fact that walking barefoot for fresh water for long periods and daily increases the risk of disease [12,21,23].

 doi:10.20944/preprints202211.0340.v1

Studies in humans in endemic areas indicate that parasite load is high. Those infected in a study in rural Brazil had an average of 8.9 lesions. The highest numbers were found in males, especially females, children <15 years and very elderly people [10,23].

In another study on the prevalence of tungiasis in the Americas for January 2007 to June 2001, PubMed and LILACS databases were used, and a manual search of publications on the topic was performed. A total of 83 articles were analyzed, with cases reported in 10 countries, and 71% of cases were in Brazil [24]. In the general population, the prevalence varied between 1.0% and 82.6% depending on several criteria. The age distribution is reported in most publications and it clearly shows that children are the most affected, with a high intensity and severity of the disease [25]. Authors report an S-shaped age curve in statistical studies, with a peak in children 5-12 years and a second peak in adults over 60 years [25, 26].

It is curious how rapid the spread of disease can be among people in resource-poor and poorly hygienic environments. In a study in northeastern Brazil, all individuals who re-entered the community after being out of the endemic area for a long time became infected within about 3 weeks [27].

Studies based in 3 South American countries have shown the importance of seasons. Immediately after the passage of active local rains and the onset of the dry season, the incidence of tungiasis increases about threefold [25, 26].

5. Discussion and conclusion

Over the past 20 years, studies in endemic areas on tungiasis have clarified to some extent the scientific community's knowledge of the epidemiology and risk factors in the Americas. All studies highlight that sand flea transmission occurs mainly indoors in resource-poor settings. Although cases occur year-round, it is undeniable that they increase sharply during the dry season. A particular challenge is the fact that *Tunga penetrans* parasitizes a large number of hosts. This makes the parasite highly prevalent in endemic areas. So-called integrated interventions are proposed in this case. These are based on the One Health approach and require large-scale cross-sectoral support to reduce DNDi, as those living in these endemic areas often also suffer from a range of other DNDi [24,27,29]. Remarkably, despite the demonstration of the S-model, sick children ≤1 year are also found in US communities. Typically, these children are carried on the mother's hips or back and have no contact with soil, and the fact that they are found ill at such a young age speaks to the seriousness of the problem [30].

This review shows that there are still large knowledge gaps regarding the prevalence and magnitude of tungiasis in America and SSA. This is why some key urgent measures are needed, such as identifying the places where tungiasis is most intensely prevalent, assessing the severity of symptomatology in relevant areas; including by age groups. It is important to identify the risk factors and the main animal species acting as reservoirs. Many authors recommend the development of entomological methods to better understand the transmission of the parasite in different settings and to assess the socioeconomic impact of tungiasis on the community [31,32].

Funding: This research received no external funding

Data Availability Statement: The data of this study are available from the corresponding author on request

Conflicts of Interest: The authors declare no conflict of interest.

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