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Review on Tungiasis: Neglected Tropical Diseases of Resource Poor Community

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Abstract

Tungiasis is caused by *Tunga penetrans* (Siphonaptera: Tungidae), a female flea which can burrows in to the host skin (humans and animal). Tungiasis is endemic on the American continent Caribbean islands and sub–Saharan Africa. People living in poor dwellings are at a better risk of tungiasis. Behavioral, socioeconomic and environmental factors are major risk factors. Domestic animals, such as pigs, dogs and cats are important reservoirs. The most common site of infested area is the feet (interdigital skin and subungual). Local inflammation, auto-amputation of digits, deformation and loss of nails, formation of fissures and ulcers, gangrene and walking difficulties are some of the clinical symptoms. Secondary infection also poses considerable risk. Tungiasis is diagnosed by identifying lodged fleas under the skin, usually as a dark and itching spot in the epidermis and morphology, site of the affected body part and a history of visiting an epidemic area. It is confirmed by microscopic/Dermoscopy. Histopathological examination showed hyperkeratosis, parakeratosis, and acanthosis of the skin. The standard treatment of tungiasis is surgical extraction of the flea under sterile conditions. Topical application of dimethicone, Zanzarin, ivermectin, Salicylated petrolatum, metrifonate, and thiabendazole are reported as effective for tungiasis. Infestations are often prevented and controlled by wearing protective clothing, spraying insecticides, sweeping floors and personals hygiene. There is limited number of studies on tungiasis in Ethiopia and little is known about the disease, therefore further studies should be initiated and funded.

Background

Tungiasis is caused by *Tunga penetrans* (Siphonaptera: Tungidae). People living in poor dwellings are at a better risk of tungiasis. Behavioral, socioeconomic and environmental factors are major risk factors. Domestic animals, such as pigs, dogs and cats are important reservoirs. Local inflammation, auto-amputation of digits, deformation and loss of nails, formation of fissures and ulcers, gangrene and walking difficulties are some of the clinical symptoms. Secondary infection also poses considerable risk. There is limited number of studies on tungiasis in Ethiopia and little is known about the disease, therefore further studies should be initiated and funded.

Conclusion

People living in poor dwellings are at a better risk of tungiasis. Behavioral, socioeconomic, and environmental factors are major risk factors. Domestic animals, such as pigs, dogs and cats are considered as important reservoirs. The most common site of infested area is the feet (interdigital skin and subungual). Clinical description and early symptoms are unnoticed and the common symptoms are severe local inflammation, auto-amputation of digits, deformation and loss of nails, formation of fissures and ulcers, gangrene and walking difficulties. Secondary infection also poses considerable risk. The parasite is diagnosed by identifying lodged fleas under the skin and confirmed by microscopic examination. Histopathological examination of the skin is also possible. The standard treatment of tungiasis is surgical extraction of the flea under sterile conditions. Topical application of medication is also effective. Prevention and control are possible by wearing protective clothing. Appropriate intervention measures must be instigated to reduce prevalence and intensity of the infestation substantially. There are limited numbers of studies on tungiasis in Ethiopia and little is known about tungiasis, therefore further studies should be initiated and funded.

Keywords: Tungiasis; *Tunga penetrans*; Reservoirs

Introduction

Jigger flea, *Tunga peneterans* (Siphonaptera: Tungidae), also known as sand flea, or Chigoe is an ectoparasite which causes Tungiasis, parasitic condition of humans and animal. The jigger flea, *T. peneterans*, causes debilitating disease in resource poor populations throughout Latin America, the Caribbean, and sub-Saharan Africa. Millions of people are at risk of infection in more than 70 nations, mostly in developing countries [1]. The importance of Tunga infestation is localization in the foot and causing serious difficulty in walking, reducing the infected person's ability to work normally and in endemic areas, prevalence ranges from 15-40% [2]. In Africa, the ectoparasite is found in the whole sub-Saharan region: from Sierra Leone, Ivory Coast, Nigeria, Ethiopia to South Africa; it also occurs in Zanzibar and Madagascar [3].

Literature Review

Historical background

The sand flea *T. penetrans* is among the few parasites, which has longitudinally spread from the Western to the Eastern hemisphere. The initial case of tungiasis was investigated in 1526 by Gonzalo Fernández where he discussed the skin infection and its symptoms on crew members from Columbus's Santa Maria after they were shipwrecked on Haiti [2]. The sand flea was first discovered in Latin America in 17th century [1]. Originally, the *T. Penetrans* occurred only on the American continent and then flea came to Angola with ballast sand carried by the ship Thomas Mitchell that left Brazil in 1872 and accidentally introduced in Senegal within the same century along with human transportation across the ocean. The fleas transported to Tanzania during the travels of Henry Morton Stanley in 1871, during colonial period. In 1899, the fleas reached Madagascar with Senegalese troops of the French army and later spread to several parts of Africa and returning British troops brought *T. penetrans* to the Indian Subcontinent in the same and the parasite, though, never established there [4,10]. Within a few years, *T. penetrans* spread from Angola along with trading routes and with advancing troops in the entire sub-Saharan Africa, including areas with tropical rainforest. At the end of the 19th century the sand flea reached East- Africa and Madagascar [1] [11].

Epidemiological distribution

Tunga penetrans is endemic in Latin America, the Caribbean and sub-Saharan Africa. Scattered occurrence has been reported in parts of Asia and Oceania. In Latin America, it is found in regions spanning Mexico to Northern Argentina and Chile [33]. Within endemic areas the tungiasis has a patchy like distribution and it occurs in underdeveloped communities in the rural hinterland, in secluded fishing villages along the coast and in the slums of urban centers [4]. Tungiasis is highly associated with the presence of dry ever sandy soils and but may also be found in the rain forest as well as in banana plantations farms located on laterite soil. Similar to other many parasitic skin diseases, the occurrence of severe tungiasis is linked to poverty. In poor communities in Brazil, Trinidad and Nigeria, studies have shown a point prevalence rates ranging between 16% and 54% [5][6]. Prevalence and parasite burden are correlated, and commonly individuals harbor dozens of fleas inside and shows a characteristic seasonal variation with highest prevalence in the dry season [7]. Tungiasis has been observed in different animals such as elephants, monkeys, cattle, sheep, goats, dogs, sylvatic rodents, cats, pigs, coatis and armadillos are important animal reservoirs. In a survey in a slum in Northeast Brazil, 67% of dogs and 50% of cats were found to be infested [8,6,9].

Demographic characteristics

Tungiasis is caused by T. penetrans, a female flea which can burrows in to the host skin. Jigger transmission directly from one person to a different isn't possible, but easily occurs through insanitary environment [12]. When eggs are laid, the young fleas hatch and find the next host in the natural environment. *Tunga penetrans* have been documented to use various mammals as reservoir host. These include humans, pigs, cats, rats, bats, sheep, cattle, donkeys, monkeys, and birds [13]. These hosts indirectly propagate the disease by being the origin of the next generation of fleas. Once the female fleas expel 100-200 eggs the cycle of transmission begins again. Several studies in this area have consistently shown tungiasis prevalence of between 16-55 % in typical endemic areas with a peak in children of about 5-14 yrs, and to a lesser extent in old age of 55 and above years [14]. In these studies, males have been observed to be slightly more susceptible [6].

Public health implication

In many poor communities of Africa, the Caribbean and particularly the American tropics, human tungiasis is locally prevalent, associated with sandy soils, and causes considerable human morbidity [1] [9]. In humans, the swelling of Tunga females causes a really irritating condition referred to as tungiasis [30]. Despite its notoriety, the jigger flea is not regarded as a serious threat to health [18]. Unfortunately, this is a common misconception. Tungiasis results in significant morbidity, manifesting itself in a number of symptoms such as severe local inflammation, auto-amputation of digits, deformation and loss of nails, formation of fissures and ulcers, gangrene and walking difficulties. Secondary infection also poses considerable risk; many lacking immunizations are vulnerable to tetanus (Clostridium tetani), often proving fatal. Complaints of insomnia are also not uncommon due to the intolerable itchiness of the infestation [5]. In addition, in non-vaccinated individuals, tungiasis predisposes and contribute to transmission of blood borne pathogens such as Hepatitis B Virus (HBV) and HIV if non-sterile instruments are used to remove embedded sand fleas and are subsequently shared between household members [20].

Etiology

Taxonomy and morphology

From the 13 known species of Tunga, T. penetrans is the most random, having been found on hosts belonging to different orders of mammalians, including Cingulata, Pilosa, Artiodactyla, Perissodactyla, Carnivora, Rodentia, Primates, and Proboscidea; in total, T. penetrans has been found on 27 genera of untamed and domestic animals [23].

Identification requires an extensive knowledge of flea morphology. Recent molecular data have explored phylogenetic relationships at the ordinal, familial, and generic level. The Siphonaptera is monophyletic and most closely associated with Boreidae (snow fleas, Mecoptera). Their recent analyses supported four genes show that plenty of extant families are paraphyletic and thus warrant a reorganization of taxonomy.

Biology and behavior

Tunga peneterans are the smallest known fleas, the basic body length of adults being only 1 mm, although after

penetrating the host epidermis, the gravid female Tunga undergoes peculiar hypertrophy to become a globular neosome. In its host (both humans and domesticated animals), the gravid female flea undergoes significant growth, will grow to around 2000 times its size in six days, eventually reaching a diameter of up to 12 mm [31] [30].

Embedded with its hindquarters at the surface of the skin and the flea is evident as a distinct, characteristic lesion on the skin which is a globular white mass with a black dot at its center point [26]. The perforation of the skin not only allows for the flea to respire, it helps also for the discharge of newly made eggs into the surrounding environment [27]. It breathes, defecates, and expels the eggs through abdominal cone. After the death of the flea, the remains of the female sand flea are discarded from the epidermis by tissue repair mechanisms [28].

The Tunga parasitic flea is generally lives in the soil or sand, and feeds intermittently on warm blooded host such as human beings, pigs, dogs, cats and chicken. Development requires dry and warm soil with an optimal temperature range between 22 and 31°C in the upper level of the soil [13] [28]. It has been suggested that fecal material released by embedded Tunga females could have pheromonal properties attracting others, which could explain the aggregation of females embedded in cluster, as well as helping males to find embedded females [28].

Reproduction fitness and Life cycle

Females have a depression or groove at their abdominal end whereas the males have their protruding copulatory organs therein same region. These morphological differences reflect the way the male and feminine copulate. Within the initiative toward copulation, the feminine penetrates an organism. It's only there that the male will find her and copulate. Copulation of adults has not been observed within the wild. With the feminine reproductive organs pointing outward, the male places its reproductive organs to copulate [32]. Copulated takes a few seconds to 2 minutes after which, the male takes search for another female. After copulation, the male dies, although sometimes it may take a blood meal before dying. Interestingly, eggs will be expelled whether or not they have been fertilized [29]. In fortnight, it releases about 200 eggs through the orifice which falls to the bottom or adheres on to the host. The flea then dies and is sloughed by the host's skin leaving a hole full bacteria and pus [28].

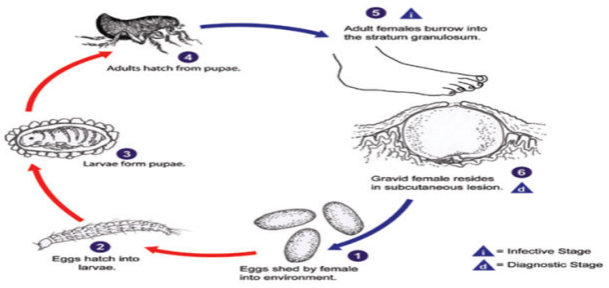

Figure 1: The life cycle of T. penetrans flea showing a complete metamorphosis cycle, CDC

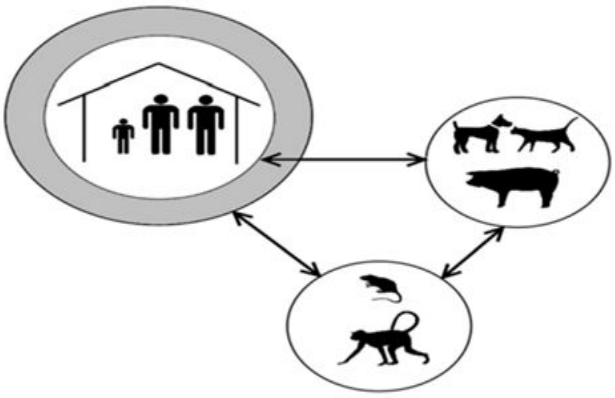

Figure 2: Human, animal and sylvatic transmission cycle of T. penetrans in Tropical enviroment.

After eggs are lay by the gravid female into the environment, it hatched into larvae in about 3-4 days and mature into adult fleas within 3-4 weeks of the cycle. It has two distinct larval stages before forming the actual pupae [32]. Larvae then hatches into pupae that are in cocoons and sometimes covered with debris from the environment like sand and pebbles. Under favorable conditions, the pupa emerges as adult during a few weeks, but under adverse conditions, the pupal period could also be prolonged to the maximum amount as a year. The adult may remain within the cocoon for an extended time until vibrations indicating the presence of a possible host stimulate it to emerge and become active [1]. The adult hatch from pupae and hunt down a warm-blooded host (mammals and birds) for getting blood meals and complete its cycle [20].

Risk factors

Different risk factors influence the prevalence of tungiasis in endemic areas. People living in poor dwellings like houses with sandy floors are at a better risk of tungiasis. Poverty, and behavioral attributes associated with age and gender also combine with environmental risk factors to make epidemiological hotspots [15,16]. The levels of resource and poverty hinder people's access to water and soap to keep their hygiene which increases their vulnerability to jigger infestation. Tungiasis is highly prevalent and found among communities with limited resources in several Countries within America, Asia and Africa[10]. Social attitudes and superstition play a great role in jigger identification and case presentation. In most cases fleas are normally removed by the patients or caretakers and due to this physician's awareness of the diseases is deficient and lesions are not brought to the attention of medical professionals, so physicians consider tungiasis to be nuisance rather than an important infection [17]. Inadequate health facility and treatment modalities are also one of the factors that determine the prevalence of tungiasis in the rural and urban settings. It has been further explained in studies from Brazil that those working at health facilities feel they do not have the resources to treat those with jiggers due to a lack of drugs[9]. Poor housing and sharing of houses with domestic animals play another important role in tungiasis. In many areas, occurrence of tungiasis high

where animal hosts such as pigs, dogs, cats, and peri domestic rodents such as rats are present in the home environment, have also been attributed with an increased risk of getting tungiasis [10] [9].

Reservoirs, ecology and transmission

The presence of various animal species in households may contribute to poor environmental sanitation and overall poor animal management particularly regarding ectoparasite control. Poor environmental sanitation confers favorable conditions for off-host sand flea development and propagation [18]. Domestic animals, such as pigs, dogs and cats have been repeatedly considered as important animal reservoirs, but data are scarce. Peri domestic rodents such as Rattus rattus are also important reservoirs [9].

The Primary habitat for T peneterans is dry, warm soil and sand of beaches, stock farms, and stables. During contact, the flea invades unprotected and intact skin of the host. The most common site of infested area is that the feet (interdigital skin and subungual area of the host). The T. flea has limited ability of jumping, so infestation occurs only on areas of skin that is at the lower extremity and exposed to sandy soil during which the fleas live around. Usually, nonfertilized female and male flea feed intermittently on warm-blooded hosts, but only the feminine flea can produce the standard skin lesion of tungiasis [21]. Once impregnated, the female flea anchors itself to the skin by using the sharp mouthparts and burrows into the epidermis of the host near the plantar surfaces of the foot and interdigit and around the periungual region. The flea expands, often reaching 1 cm in diameter to accommodate large area of the dermis. The head is down into the dermis for feeding from blood vessels, while the caudal abdominal portion is at the skin surface, often forming a punctum or an ulceration which is used for air breathing [22].

Clinical Manifestation

As the flea cannot jump very high, infestation is typically limited to the feet and digits. Penetration mostly occurs in the periungual region (area under the nail) but can also occur in any other part of the bod [23]. The parasite selectively infects the peri- and subungual folds of the toes, interdigital spaces, soles, and heels. infestation at other sites, including the hands, genitals, groin, face, elbows, wrists, breasts, back, thighs, knees, and legs, has also been reported during a few case [11] [35].

Clinical description and early symptoms of infestation are usually mild and, therefore, usually unnoticed. Itching intensifies and swelling develops as the female flea increases in size. The affected individual also develops soreness or pain, which limits walking ability [11]. Early indications for tungiasis in human and animals include a red-brownish spot of approximately 1-3 mm in diameter, with visible posterior segments of penetrated flea occurring in the early stage. Towards maturity of the *Tunga penetrans*, there is evidence of circular lesions of about 1-4 mm in diameter, presenting as a white patch with a central black speck showing posterior segments [9].

Diagnosis

Generally, in endemic areas, the diagnosis of tungiasis is usually made by macroscopic inspection of the lesion and the idea of the standard morphology and site of the affected body part and a history of inhabiting or visiting an epidemic area [2] [36]. It is primarily diagnosed by identifying lodged fleas under the skin, usually as a dark and itching spot in the epidermis. The spot in the epidermis has a diameter of between 1-2 mm and is usually itchy and painful to the victims. Lesions with a central black dot and or brownish-black circular crust presenting as a white halo 3–10 mm in diameter are also diagnostic as a presumptive case. When lodged fleas die, lesions present as circular black crusts with punched out fleas residues, and necrosis of the skin [11][28]

Clinically, even the untrained physician can diagnose the ectoparasite taking into account the typical topographic localizations and the natural history of the disease. The patient typically complains about local itching, pain and therefore the sensation of a far-off body. Patients commonly report having walked in infested places like beaches and farms. Most lesions occur on the nail and rim. Eggs being expelled or eggs attached to the skin and the release of brownish threads of feces are pathognomonic signs. Feces threads are of a helical structure and sometimes spread into the dermal papillae [1]. Clinical medical differential diagnosis of tungiasis includes warts, mycotic lesions, bacterial infections, foreign-body granulomas, subungual exostosis, early melanoma, tick bite, or myiasis [2] [36].

Tungiasis can be confirmed by microscopic analysis after the extirpation of the parasite from the nodule of infected host. Dermoscopy is additionally helpful for the diagnosis of tungiasis, especially for doctors in nonendemic countries, who may have difficulty in identifying the parasite due to the rarity of tungiasis cases in these areas [2] [36].

Histopathological examination showed hyperkeratosis, parakeratosis, and acanthosis. The body of the flea is surrounded by a pseudocystic cavity within the epidermis, whereas the top lies within the dermis. The flea features, a thick cuticle with prominent hypodermic cells, branched tracheal rings, distended digestive tracts, and enlarged ovaries containing numerous eggs at various stages of development. In few cases, perilesional neutrophils, lymphocytes, and eosinophils have also been reported to be found [36].

Treatment

The standard treatment of tungiasis is surgical extraction of the flea under sterile conditions [1]. However, this is often not an easy task, because it requires a talented hand and good eye-sight. The opening within the epidermis should be carefully widened with an appropriate instrument sort of a sterile needle to enable the extraction of the entire flea. If the flea is torn during extraction or if parts are left within the sore, severe inflammation is the rule. After extraction the sore should be applied with a topical antibiotic [37].

A dicomponent dimethicone, available under the name NYDA®, has been shown to cause 80%-95% of all embedded sand fleas to lose viability within a week. It is best when applied topically on to the affected area. Further, dimethicone is taken into account wholly nontoxic and really safe for extended human use [38][39]. The insectifuge Zanzarin, a lotion consisting of copra oil, jojoba oil, and burn plant, was shown to scale back the amount of newly embedded fleas and skin lesions, as well almost completely reverse the cutaneous pathology, when applied and managed two times daily [40].

Topical application of ivermectin, metrifonate, and thiabendazole are reported as effective for tungiasis. Salicylated petrolatum (20%) topically applied for a half or day in high infestations cause the death of the fleas and facilitate their manual removal of the parasite. However, these treatments don't remove the flea from the dermis, and that they don't end in quick relief from painful lesions. Other alternative reported topical medication for tungiasis include cryotherapy and electrodesiccation of the nodules [41] [42].

Prevention and Control

Infestations are often prevented by wearing protective clothing, closed footwear, and socks. In addition, measures, like spraying the bottom with insecticides and sweeping floors, are necessary for the prevention of tungiasis [2]. Daily and frequent observation of the feet and immediate extraction of embedded fleas protects against complications fleas' infestation. Closed shoes and socks seem to stop tungiasis to a particular degree although complete protection can't be achieved by these means [43].

Conclusion

Behavioral, socioeconomic, and environmental factors are identified as the major risk factors related to the prevalence and severe pathology of tungiasis. Therefore, appropriate intervention measures must be instigated to reduce prevalence and intensity of the infestation substantially [5] [18].

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