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Infection with the Sand Flea *Tunga penetrans* (Tungiasis) in a Traveller Returning from Cameroon, Africa

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Abstract

Tungiasis refers to human infection with adult fleas, *Tunga penetrans*. Although common throughout the tropics, tungiasis is rarely encountered by physicians in the United States such that it may be improperly diagnosed and inappropriately treated. We provide a case report of tungiasis in a traveler from Cameroon and a brief review of reported cases in the United States and Canada.

Introduction

Tungiasis refers to human infection with adults of the flea, *Tunga penetrans*. *Tunga penetrans* is the smallest known flea, attaining a maximum length of no more than 1 mm (Eisele et al. 2003). Common names applied to *T. penetrans* include chigoe flea, chigger flea, sand flea, bicho de pé, jigger, nigua, chica, pico, pique, and suthi (CDC 2013, Smith 2015). *Tunga penetrans* is unique in that the female flea actually penetrates and resides within the skin of its host. Although both male and female fleas take blood meals, only the female penetrates the host. After penetration, the female exhibits profound hypertrophy attaining a diameter of up to 1 cm. Eight to ten days after penetration, females begin laying eggs that are released from the host (Lefebvre et al. 2011). During the 4-6 weeks that the fleas reside in the host, hundreds of eggs may be released. Subsequently, the fleas die and are sloughed from the epidermis by skin repair mechanisms (Heukelbach 2005). After 3 to 4 days in the soil, eggs hatch and release larvae. The larvae feed on organic debris and pass through two instars before becoming pupae that are encased in cocoons normally covered in soil. The time from hatching until emergence of the adult stage is 3 to 4 weeks. The adult's main diet consists of blood from mammals where mated females burrow underneath the skin, leaving only their abdomens exposed to lay eggs (CDC 2013, Feldmeier et al. 2014). *Tunga penetrans* utilizes a wide variety of reservoir hosts including rats, dogs, cats, monkeys, goats, cattle, horses, and pigs (Heukelbach et al. 2001, Cestari et al. 2007, Feldmeier et al. 2014). The life cycle of *T. penetrans* is given in Fig. 1.

Although native to South and Central America, *T. penetrans* has become widely distributed throughout the tropics via trade routes, having become particularly abundant in sub-Saharan Africa. Although common throughout the tropics, tungiasis is rarely encountered by physicians in the United States such that it may be improperly diagnosed and inappropriately treated. Nearly all cases diagnosed in the United States resulted from international travel to countries in Africa and South and Central America. The only autochthonous reported human case in the U.S. was that of a man in New Orleans in 1929 who reportedly contracted the infection while sitting on infested sisal hemp imported from Mexico (Faust and Maxwell 1930), although Augustson (1942) reported *T. penetrans* from a Pacific Horned Owl (*Bubo virginianus pacificus*) at Oceanside in San Diego California. The purpose of this paper is to provide a case report of tungiasis in a traveler from Cameroon and to briefly review cases reported from the United States and Canada.

Case Report

During the summer of 2013, a 50 year-old male research biologist visited Bawa, Cameroon on a medical missions trip. The area comprises a tropical mountain forest with a rainy season extending from April through September. See Richardson et al. (2011) for a climatic and demographic description of the area. On 12 July, the subject noticed single small, black furuncular-like lesions on the little toe and bottom of the left foot with minor swelling and minor pain. On 13 July he returned to the United States of America. The lesions persisted with little change. On 17 July, a physician examined the subject. Patient presented furuncles on the left foot characterized by left foot paronychia of 5th digit and also an area on mid forefoot sole. Paronychia was characterized by discoloration and tenderness. The lesions were diagnosed as foreign objects with characteristic inflammation. The lesion

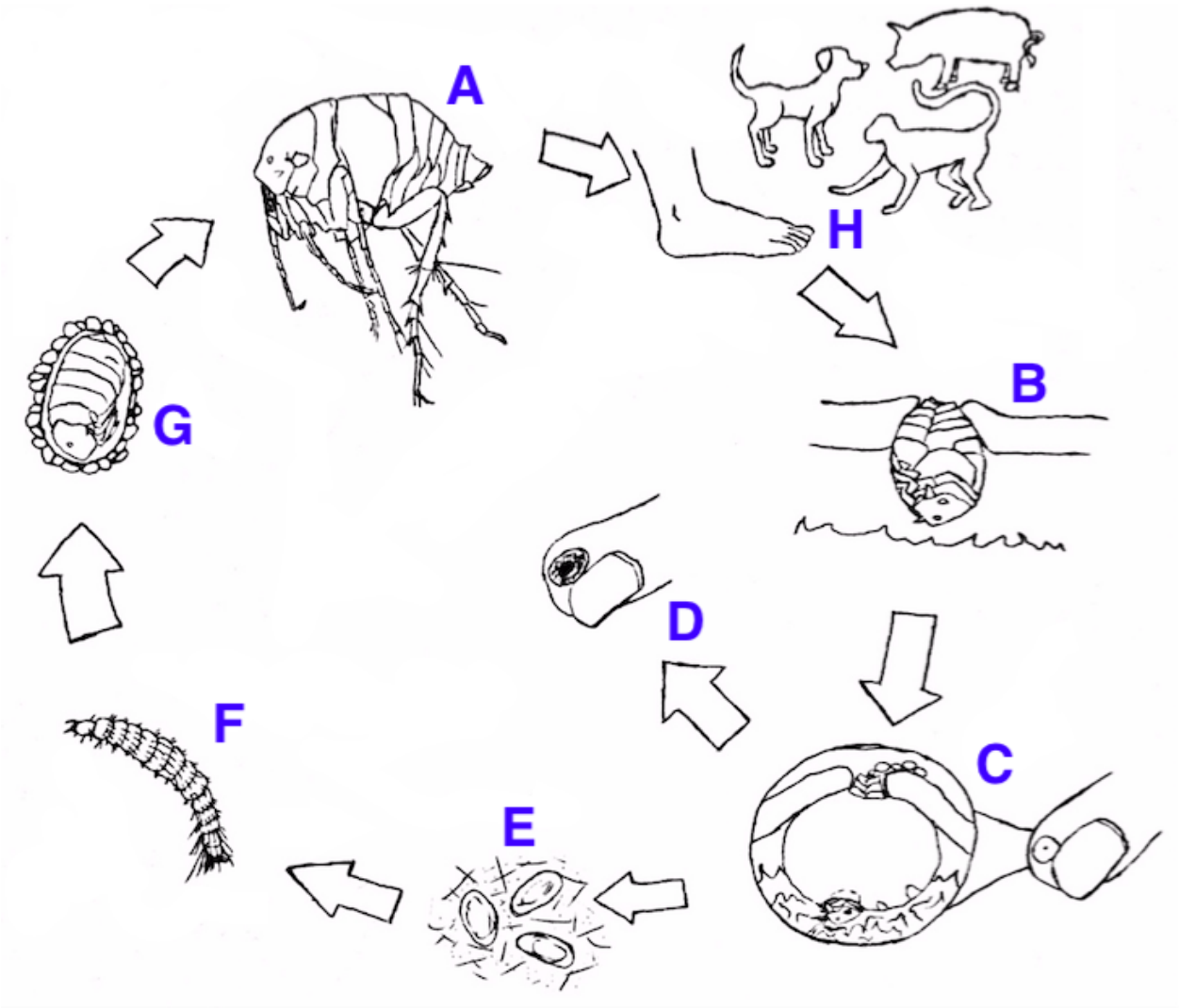

Figure 1. Life cycle of *Tunga penetrans*. After CDC (2013) with information from Cestari et al. (2007) and Feldmeier et al. (2014). **A.** The free-living adult female is a maximum of 1 mm long. Both adult male and female fleas take blood meals. **B.** The female penetrates the skin of the host, leaving the distal abdominal segments exposed so as to form a "cone" providing contact with the outer environment, through which it may breath, defecate, copulate and expel eggs. Immediately, hypertrophy of the abdomen begins and within a few days, the female attains a diameter of up to 1 cm and begins passing eggs to the outside environment. **C.** During the next 2-4 weeks the female may pass hundreds of eggs, which fall to the soil. **D.** After expulsion of eggs, involution of the lesion begins and the flea dies. Remains of the flea are sloughed off in the course of skin repair mechanisms. **E.** Eggs hatch in 1-6 days releasing larvae. **F.** The larvae feed on organic debris and pass through two instars over the next 5-7 days. **G.** Cocoons that are often covered with debris such as sand contain the puparium. Adults emerge from the cocoon after 9-15 days. **H.** Almost any domestic or wild mammal may serve as a reservoir for human infection.

on the little toe was probed with a hypodermic needle. Liberated clear fluid contained small black particles that were assumed to be parts of a foreign object. It was later determined that the "debris" were parts of the flea. Vital signs and hematological findings, including differential leukocyte counts, were not remarkable. The patient was prescribed a seven-day course of Keflex. The removal procedure was followed by an inflammatory response characterized by moderate pain and erythema. It is presumed that the ertythromaceous swelling resulted from an inflammatory response to the dead flea and fluids. This was followed a month later by necrotic discoloration (Fig. 2).

On 18 July, 8 additional furuncular lesions appeared (Fig. 3).

From 18 July to 29 July, patient reported minor pain with periodic intense pruritus associated with the "new" lesions. On 23 July, patient lanced the initial lesion on the right little toe with a sterile hypodermic needle to relieve swelling, moderate-severe pain, and

pruritus associated with the lesion. Limited cellulitis was also noted. A moderate amount of clear fluid was liberated. Within several hours, the pain, pruritus and cellulitis subsided.

Figure 2. Necrotic discoloration following attempted surgical removal. One month after procedure.

Figure 3. Early lesions associated with *Tunga penetrans*.

On 30th July, all pain associated with lesions subsided. On August 2nd the patient returned to the physician. Lesions had increased in size. Patient presented large pustular lesions with centrally located black dots under toes on right side and below right hallux nail (Fig. 4), also on the mid sole and left little toe. Based on the appearance of the lesions, diagnosis was made as furnucular myiasis associated with *Cordylobia anthropophagia*. Diagnosis was made based primarily on reference to Palmieri et al. (2013).

Figure 4. Flea below right hallux nail.

On 8 August dermal exfoliation of 4th toe of right foot was noted. On August 9, the flea began to detach from the lesion and was removed leaving an ulcer (Fig. 5). Substantial movement of the flea was observed indicating that the flea was still alive. The flea was fixed in 95% v/v ethanol and prepared for microscopic observation that facilitated the diagnosis of tungiasis. The removed flea is shown in Figs 6-9.

Figure 5. Flea, *Tunga penetrans*, detached from lesion on 4th toe of right foot on 9 August. Note dermal exfoliation and resultant ulcer.

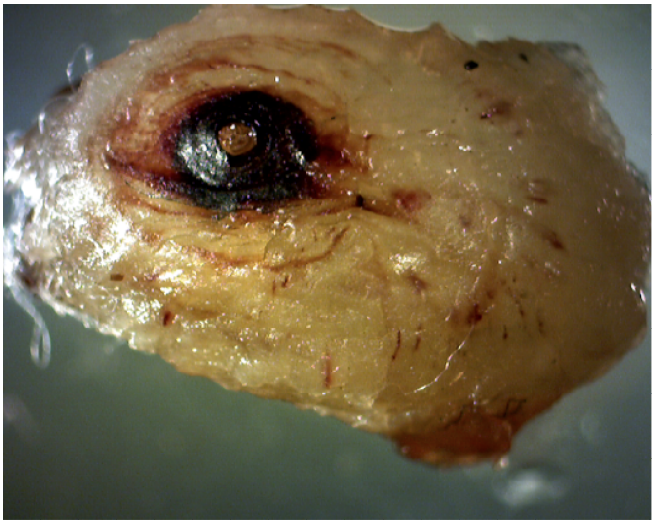

Figure 6. Posterior of flea, *Tunga penetrans*, removed from 4th toe of right foot.

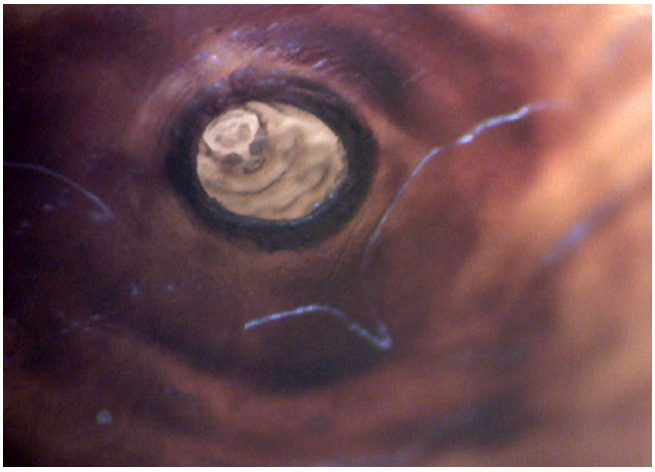

Figure 7. Close up of anal-genital opening of flea, *Tunga penetrans*, removed from 4th toe of right foot.

On the morning of 10 August, pruritus subsided. There was substantial dermal exfoliation around all remaining lesions. Pruritus resumed on lesion on the bottom of foot with moderate to severe pain and erythematous swelling (Fig. 10). Clear fluid exuded from the lesion and walking was difficult. After about an hour, pain and pruritus subsided. It is presumed that the flea had ruptured leading to an intense inflammatory response.

On 18 August, an additional flea became partially detached and was removed (Fig. 11). In total, only 2 fleas were removed. It is presumed that the remaining fleas died and were sloughed off by normal skin repair mechanisms. By early September, lesions were completely healed without sequela.

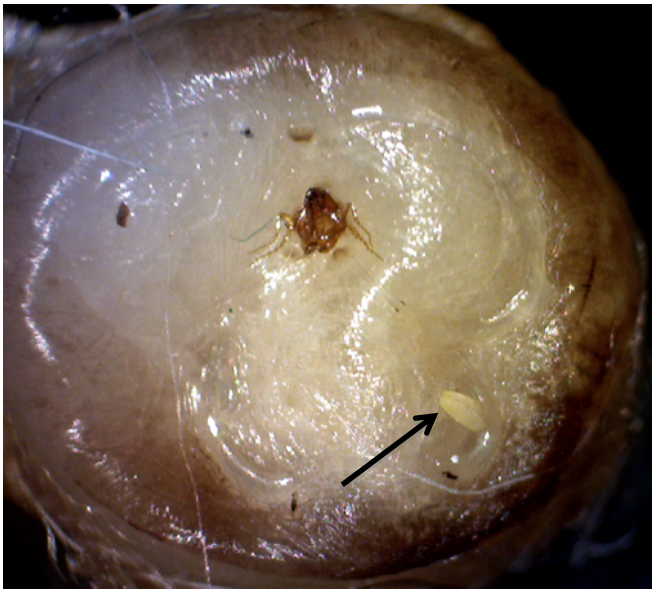

Figure 8. Anterior of flea, *Tunga penetrans* showing head. Note that the anterior portion of the flea is in the shape of a cloverleaf (Eisele et al. 2003). An egg is indicated by the arrow.

Figure 9. SEM of head of flea, *Tunga penetrans*, removed from 4th toe of right foot.

Remarks and Discussion

This case report constitutes a typical course of infection with *T. penetrans*. Although common throughout much of the developing world (Feldmeier et al. 2014), tungiasis is rarely encountered in the United States and Canada and nearly exclusively in travelers returning from endemic areas. A confounding diagnostic factor is that lesions may not appear for several days (up to 30), following penetration of adult fleas (Palicelli et al. 2016). The paucity of reports of tungiasis may result in misdiagnosis and improper

Figure 10. Swelling around flea, *Tunga penetrans*, and lesion on plantar region of right foot following "rupture" of flea on 10 August.

Figure 11. Removal of flea, *Tunga penetrans*, from underneath right hallux nail on 18 August.

treatment; therefore, it is important to educate clinicians on the presentation and course of infection of this flea. Feldmeier et al. (2014) provided an excellent brief characterization of the pathogenesis of tungiasis as follows: "The inflammatory response around burrowed viable, dead, or decaying sand fleas is the basis for the clinical and pathological manifestations. Acute inflammation—characterized by erythema, edema, pain and itching—is caused by the growth of a biologically active foreign body within the epidermis, exerting pressure on the surrounding tissue." Eisele et al. (2003) provided an excellent comprehensive overview of the course of infection with *T. penetrans*.

Tungiasis may easily be mistaken for a foreign object in early stages of infection or furuncular myiasis in later stages, as with the present case. Tungiasis is restricted to the feet 99% of the time (Thielecke et al. 2013), particularly in areas of soft skin, such as the space between toes, under toenails, and along the medial border of the feet (Cestari et al. 2007). Although rare, tungiasis should be considered a potential threat to travelers, particularly those visiting South America and Africa, as serious complications may result from secondary infections that may lead to cellulitis, abscess formation, lymphangitis, sepsis, tissue necrosis, gangrene, erysipelas, and deep mycosis (Binford and Connor 1976, Fein et al. 2001, Cestari et al. 2007). Therefore, early treatment with topical and/or parenteral broad-spectrum antibiotics is recommended (Spielman et al. 1986). Untreated tungiasis is also a risk factor for tetanus in unvaccinated individuals (Cestari et al. 2007). Additionally, inflammation may be related to the presence of endosymbiotic *Wolbachia* bacteria (Feldmeier et al. 2014), which is known to be present in *T. penetrans* (Heukelback et al. 2004).

Sanusi et al. (1989) reviewed 14 cases of tungiasis diagnosed in the United States that appear in the scientific literature. Table 1 provides an overview of the 14 cases summarized by Sanusi et al. (1989) along with 12 additional cases from the United States and one from Canada.

Wearing socks and closed-toed shoes, especially in sandy areas (Lefebvre et al. 2011), may help reduce the risk of infection although Thieleckek et al (2013) found that wearing shoes failed to reduce the incidence of infection. Application of a repellant based on coconut oil (Zanzarin) twice a day was reported to reduce infection rate by almost 100%. Treatment is extraction of fleas by enucleation with a sterile vaccionostylet, needle, or curette (Feldmeier et al. 2009, Lefebvre et al. 2011). Care should be taken not to rupture the flea, or leave any part of the flea in the lesion as this may lead to an intense inflammatory reaction (Heukelback et al. 2001, Lefebvre et al. 2011), as described in the present case study.

Table 1. Synopsis of cases of tungiasis reported in the literature from the United States and Canada, including the cases reported by Sanusi et al. 1989 and subsequently reported cases.

Reference	Reported Location	Age, Sex	Number and Location of Lesions	History of Exposure	Treatment
Faust and Maxwell 1930	New Orleans, Louisiana	Adult, M	Many around pubic and inguinal areas, lower right abdomen	Sat on sisal hemp from Mexico	Phenolized ointment
Reiss 1966	New York City, New York	Adult, M	Several on both feet	Traveled to Lambarene, Gabon, Africa	Flea removal, applying antibiotic ointment
Goldman 1976	Cincinnati, Ohio	5, F	4 on plantar, 3 on back, 1 under breast, 1 on wrist, and 1 under nail	Traveled to Africa	Debrided, irrigated with saline, bacitracin and polymyxin B sulfate ointments
Brothers and Heckmann 1979	Provo, Utah	21, M	1 on toe	Travelled to Rio de Janeiro, Brazil	Curettage, antibiotic
Taubman and Spielman 1979; Spielman et al. 1986	New York	44, F	4 on 2nd and 5th toes of left foot	Traveled to Lima, Peru	Curettage
Bell et al. 1979	Memphis, Tennessee	63, M	1 on lateral side of left heel, 1 on plantar surface, 1 under right 5th toenail	Travelled to Manaus near Ponta Negro, Brazil	Treated with cephalexin, excised fleas
Zalar and Walther 1980	New York	29, F	Several on both 1st toes and 5th toe of right foot	Traveled to Ethiopia, Tanzania, and Kenya	Curettage, bacitracin ointment
Poppiti et al. 1983	Miami, Florida	25, M	Several on lateral sides of both feet	Travelled to Brazil	Flea removal
Armin et al. 1985	Maywood Illinois	70, M	1 under toenail of 2nd toe right foot	Travelled to Africa	Flea removal, topical antibiotic bacitracin
Wentzell et al. 1986	Hanover, New Hampshire	17, M	2 on periungual area of 1st and 5th toes on right foot	Travelled to Brazil	Curettage, dissected bluntly, antibiotic ointment
Milgraum and Headington 1988	Ann Harbor, Michigan	30, M	1 on 2nd toe	Traveled to Canaima National Park, Venezuela	Not Given
Sanusi et al. 1989	Shreveport, Louisiana	24, M	2 on 3rd and 2nd toes of right foot	Traveled to Zaire, Africa	Flea removal
Dalton and Haldane 1990	Halifax, Nova Scotia, Canada	43, M	1 on sole of right foot	Travelled to Venezuela	Debrided with sterile needle
Burke et al. 1991	Greenville, North Carolna	18, M	Distal lateral portion of right great toe	Travelled to Brazil	Excised with scalpel blade and base curetted, topical polymycin B & bacitracin ointment
Lowry et al. 1996	Fort Bragg, North Carolina	Adult, F	Feet and toes	Travelled to Brazil	Curettage
Mashek et al. 1997	Buffalo, New York	33, F	Many on plantar and periungual areas on both feet	Immigrated from Somalia and lived in Kenya	Debrided, curettage, dicloxacillin, bacitracin ointment
Lucchina et al. 1997	Massachusetts	30, F	Several on 1st and 5th toes of right foot	Traveled to Brazil	Curettage, electrodesic-cation
Darmstadt and Francis 2000	Seattle, Washington	1, F	5^{th} toe of right foot	Adopted from Paraguay	Nail clipped back, unroofed and debrided

Table 1 Cont.

Fein et al. 2001	Cincinnati, Ohio	4, F and 6, M	Many on soles and toes of both feet	Adopted from Liberia, Africa	Flea removal, antibiotics
Brane et al. 2005	Cincinnati, Ohio	29, F	1 on 1st toe of left foot	Traveled to Kenya	Flea removal, antibiotic ointment
Van Buskirk et al. 2006	Detroit, Michigan	55, F	Right heel	Traveled to Tanzania	Excisional biopsy
Hager et al. 2008	Texas	24, F	1 on left first toe	Traveled to Tanzania, Africa	Curettage, and light hyfrecation
Appiah et al. 2013	Baltimore	14, M	20 on right foot, 9 on left foot, soles and sides	Traveled to Guyana, South America	Topical 10% albendazole ointment, curettage

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