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Background: The jigger flea (*Tunga penetrans*) is a parasitic insect that causes debility in resource-poor communities of the developing world. The flea originates from South America, but it has spread across the Caribbean, Sub-Saharan Africa and parts of South Asia. Virulence, known as tungiasis, results from infestation by the fertilised female flea, which embeds into the epidermis (usually of the feet), feeds on lymph and swells as the eggs grow. The mature eggs are extruded onto the ground, where the larvae feed, pupate and metamorphose into the adult flea.
Aim & Objectives: To ascertain the prevalence and impact of *Tunga penetrans* in a rural population of North-west Cameroon, in relation to a series of associated risk factors.
Method/Study Design: In July and August 2008, a survey was carried out across a representative sample of compounds within nine villages in the Ndu sub-division of North-west Cameroon. The residents were questioned in relation to suggested risk factors, as well as local treatments and folklore. Their hands and feet were examined for the presence of tungiasis, and the number and locality of lesions were recorded.
Results/Findings: 1,151 individuals were examined, including 567 males (49%) and 584 females (51%). Of these, 53% were children (0-14 years), and 10% were elderly (60+ years). In total, 610 individuals (53%) were infested with *Tunga penetrans*. Prevalence was higher in males (59%) than in females (47%) (p=0.004). Prevalence was highest in children, decreased in adults and increased again in the elderly. Illiterate people were more likely to suffer (59%) than those who were literate (50%) (p=0.05). The mean parasite intensity was 5.1, and the median parasite intensity was 2 (interquartile range, 2-5). Of those surveyed, 769 (67%) had experienced the flea within the previous month, and 21% of the study sample did not consider jigger flea infestation to be a disease.
Conclusion: The prevalence and impact of tungiasis in rural areas of North-west Cameroon are high, causing suffering and disability to a large proportion of the population. The disease remains an important health problem to the impoverished, and needs to be addressed by health officials, the medical community, educationalists and sufferers themselves.

Key words: *Tungiasis,* Tunga penetrans*, jigger flea, epidemiology, parasite, Cameroon.*

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Tungiasis: A Neglected Health Problem in Rural Cameroon

Introduction

Common to Latin America, Caribbean and Sub Saharan Africa, the colloquially named 'jigger flea' is known to cause significant debilitation in areas of deprived resources and infrastructure. Tungiasis, a neglected ectoparasitic disease, arises when the female jigger flea, *Tunga penetrans*, burrows into the epidermis of its host. The jigger flea is the smallest known flea, measuring under 1mm in length (Feldmeier *et al*., 2004, p. 279). Having entered its host (both humans and domesticated animals), the gravid female flea undergoes substantial growth, growing to around 2000 times its size in six days (Figure 1).Embedded with its hindquarters at the surface of the skin, the flea is evident as a distinct, characteristic lesion on the skin; a globular white mass with a black dot at its centre (Joseph *et al*., 2006, p. 971). This slight perforation of the skin not only allows for the flea to respire, but also for the discharge of newly made eggs. Within a week, up to 200 eggs are deposited onto the ground. These eggs then hatch into *Tunga penetrans* larvae which feed on organic detritus and develop, via a pupal stage, into a fully grown jigger flea. Re-infestation occurs and the cycle is complete (Gordon, 1941, p. 48). Writing in 1525, Gonzalez Fernandez de Oviedo y Valdes is thought to be the first to document the flea in South America. It is believed the jigger flea eventually left the confines of the Americas amongst the sand ballast of the Thomas Mitchell, a ship travelling from Brazil to Angola in 1872 (Gordon, 1941, p. 47). From here, the flea infiltrated Western Africa and then into the heart of the continent leading to its widespread presence in Sub-Saharan Africa today (Joseph *et al*., 2006, p. 971).

Despite its notoriety, the jigger flea is not regarded as a serious threat to health (Ugbomoiko, Ofoezie, Heukelbach, 2007, p. 476). 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 immunisation are vulnerable to tetanus (*Clostridium tetani*), often proving fatal. Complaints of insomnia are also not uncommon due to the intolerable itchiness of the infestation (Muehlen, Feldmeier, Wilcke, Winter, Heukelbach, 2006, p. 372).

To evaluate the scale of this neglected problem, the study aimed to ascertain the prevalence of tungiasis in a number of rural settings in the North West Province of Cameroon. Through a comprehensive, locally administered questionnaire, we also aimed to identify any risk factors or preventive measures and assess their impact on this well known, but poorly handled health problem.

Figure 1: Life cycle of *Tunga penetrans*. (Gordon, 1941, p. 47; Nagy *et al.,* 2007, p. S237)

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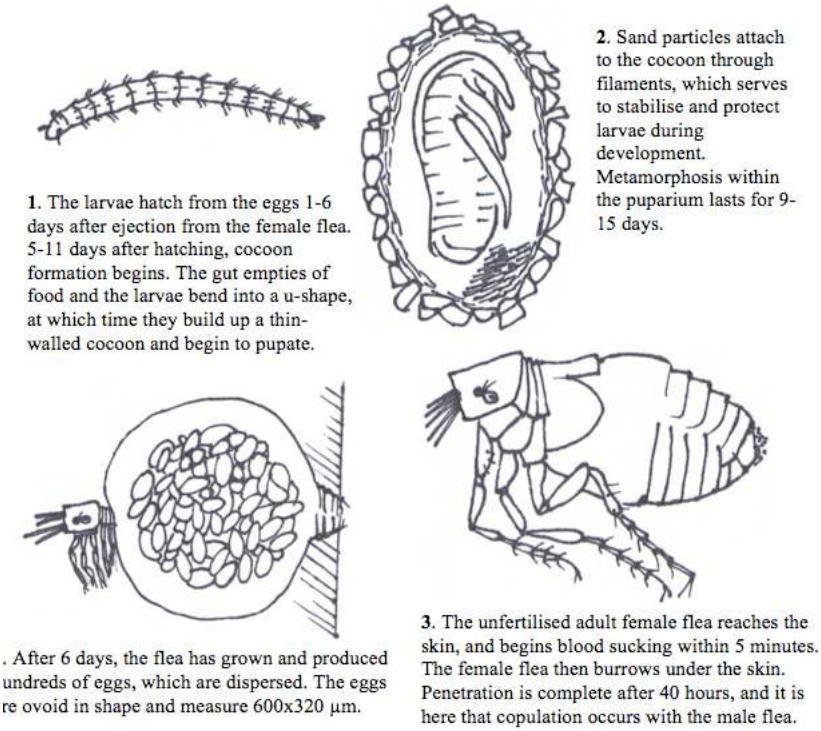


1. The larvae hatch from the eggs 1-6 days after ejection from the female flea. 5-11 days after hatching, cocoon formation begins. The gut empties of food and the larvae bend into a u-shape, at which time they build up a thin-walled cocoon and begin to pupate.

2. Sand particles attach to the cocoon through filaments, which serves to stabilise and protect larvae during development. Metamorphosis within the puparium lasts for 9-15 days.

. After 6 days, the flea has grown and produced undreds of eggs, which are dispersed. The eggs re ovoid in shape and measure 600x320 µm.

3. The unfertilised adult female flea reaches the skin, and begins blood sucking within 5 minutes. The female flea then burrows under the skin. Penetration is complete after 40 hours, and it is here that copulation occurs with the male flea.

Materials and Methods

Study Area and Population

This cross sectional study was carried out among townships within the Ndu subdivision of the Northwest Province of Cameroon, an anglophone region lying 300km from the capital city, Yaounde, and 100 km north of Bamenda (see Figure 2). The population of the Ndu subdivision is 86,322 inhabitants. Agriculture is the most common occupation and the area is renowned for its large tea plantations.

In the rural outskirts of the subdivision, houses are found on large compounds, which are governed by traditionally elected chiefs or 'Fons'. In general, the buildings have a very basic structure with dusty, mud floors, no running water or electricity. To understand the living conditions better, a questionnaire regarding each compound was completed. On average, there were 7 people living in each household, often consisting of three or more familial generations.

Figure 2: Study area

Study Design and Data Collection

This part of Cameroon lies about 800 km north of the equator and experiences annual dry and wet seasons. This study was conducted for 45 days in July and August 2008, which fall in the middle of the wet season.

During this time, a total of 1,151 people (occupying a representative sample of 50 randomly selected compounds) were interviewed using a pretested, locally approved questionnaire and clinically examined for the presence of *Tunga penetrans*.

Prior to obtaining any results, a preparatory phase was carried out, in which draft questionnaires were piloted and all aspects of the study were discussed and explained at meetings with the Fons of each village. At an individual level, the study was explained and oral consent was obtained before any data collection proceeded. Participation in the study was completely voluntary and anonymous.

Interviews were carried out with all those participating in the study. To help identify potential risk factors for tungiasis, a questionnaire was administered to evaluate demographic, educational and behavioral variables, as well as any existing preconceptions or understanding. Parents or guardians were responsible for answering the questionnaire for any children who were themselves unable to respond.

Every participant was then clinically examined. Although ectopic lesions have been reported (Heukelbach *et al*., 2002, p. 215), only the hands and feet were examined in order to respect individual privacy. The following diagnostic criteria were considered to be indicative of tungiasis: a circular, white lesion with a central black dot (4-10mm diameter); a black thickening surrounded by necrotic tissue; and partially or totally removed fleas leaving a characteristic, exposed sore in the skin (Ugbomoiko *et al*., 2007, p. 476). The number and location of lesions were recorded. In particularly severe cases, a trainee nurse removed the embedded fleas, administered first aid to prevent secondary infection and also referred the patient to their nearest medical centre for tetanus vaccination. A detailed history was taken in these cases in an effort to identify possible causes of such heavy infestations.

Ethical Considerations

Following submission of an account of its ethical implications, this study was approved by the Ethics Committee of the Royal Geographical Society. Whilst in Cameroon, we organised formal meetings and discussed the study at length with the Fon of each village. The study was explained fully and approved by all nine local authorities. All individuals remained anonymous and gave oral consent (a parent or legal guardian consented for children). Assurance was also provided that results would be confidential.

Statistical Analysis

Written data were entered into the Epi Info software package (version 6.04d; Center for Disease Control and Prevention, Atlanta, USA), and double-checked against the original questionnaires. The data were exported to Microsoft Excel 2008 Version 12.0 for analysis.

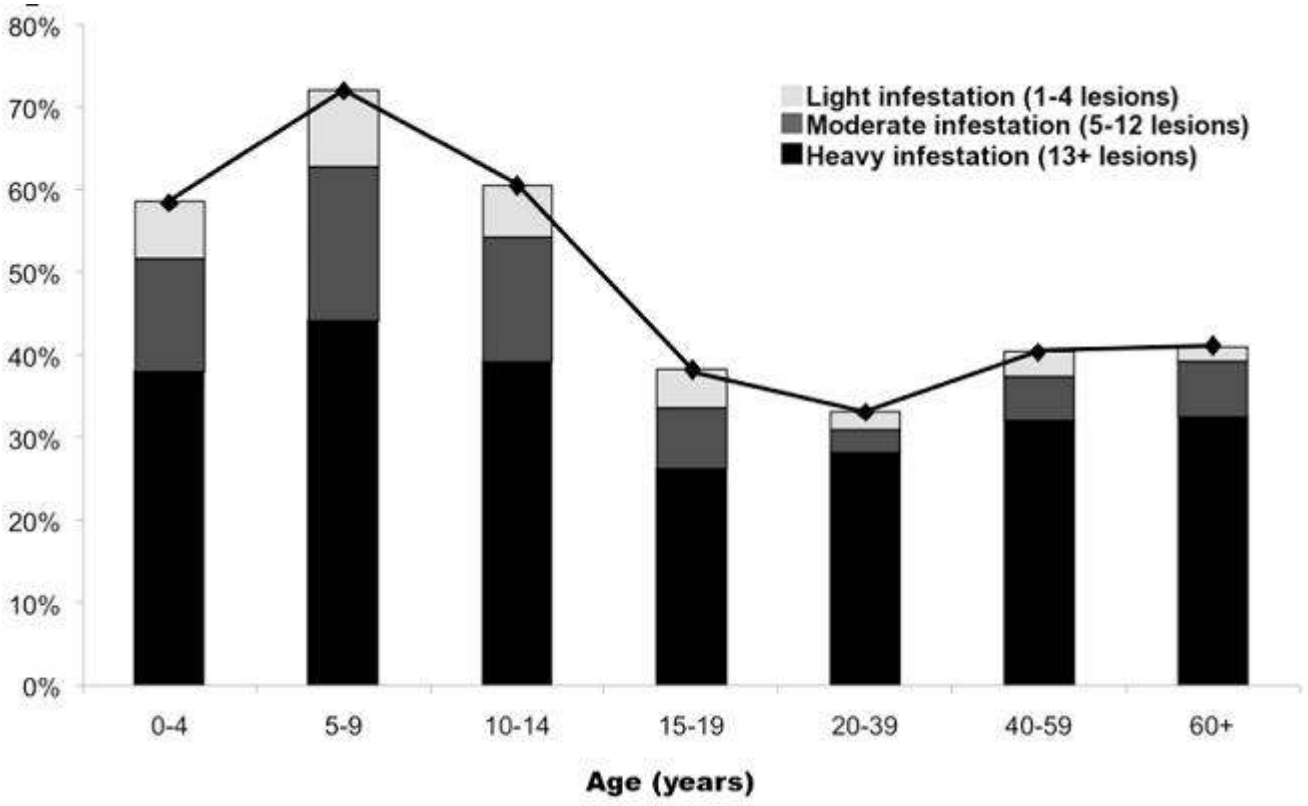
Fisher's exact test was applied to determine the significance of difference of relative frequencies. Use of median and interquartile range data indicated where results were not normally distributed.

Results

In all, 1,151 individuals from 50 compounds in nine villages were surveyed. Of these individuals 567 (49%) were male and 584 (51%) were female. In total, 610 were infested with *Tunga penetrans*, resulting in a point prevalence of 53% (95% confidence interval, 50%-56%), although 65% had experienced the flea in the past month. 336 males (59%) and 274 females (47%) were infested, indicating a significant difference in prevalence between the two sexes (P=0.004).

The median age of interviewees was 13 years (interquartile range 9-33.5 years). Interestingly, the distribution by age followed a characteristic curve (see Figure 3). Generally speaking, the young were worst affected. Prevalence dropped in adults and then increased slightly in the older population (Table 1).

Figure 3



All affected individuals had lesions on the feet, most of which presented in the periungual region. Across the whole study, a total of 3103 parasitic lesions were recorded, 2991 (96%) of which presented on the feet and 112 (4%) on the hands, resulting in a mean parasite intensity of 5.1 and a median parasite intensity of 2 (interquartile range 2-5). Males showed a much higher parasite load (median of 3, interquartile range 1-7 lesions, mean 6.7) than females (median of 2, interquartile range 1-2, mean 3.1). The maximum number of fleas on an individual was 102 (see Case Study), and the highest number of parasites experienced at one time was, on average, 8.1.

Of those people infested with *Tunga penetrans*, 415 (68%) suffered from light infestations (1-4 parasites), 132 (22%) from moderate infestations (5-12) and 63 (10%) from heavy infestations (13+).

Table 1

Age Group	Examined	Positive	Prevalence (%) (95% conf. limits)
0-4	29	17	58.6 (40.7-74.5)
5-9	315	227	72.1 (66.9-76.7)
10-14	271	164	60.5 (54.6-66.2)
15-19	107	41	38.3 (29.7-47.8)
20-39	181	60	33.1 (26.7-40.3)
40-59	131	53	40.5 (32.4-49.0)
60+	117	48	41.0 (32.5-50.1)
TOTAL	1,151	610	53.0 (50.1-55.9)

Infestation appeared to be more common in those who did not consider tungiasis a disease, but the sample was too small to be significant (p=0.35). Prevalence in the illiterate (59%) was greater than in the literate (50%) (p=0.05). Believing not to be a disease, does not increase the risk of infection (p=0.34).
The most common treatment method, used by 98% of the interviewees, was physical removal of the flea with a

sharpened stick (augering). 59% would not consider visiting a medical centre to obtain treatment for tungiasis.

Discussion

Tunga penetrans has many common name synonyms, which provides a good indication of its internationally widespread prevalence (Sachse, Guldbakke, Khachemoune, 2007, p. 11). Given this, epidemiological data for tungiasis in Africa are sparse. A recent urban study in Cameroon found a high prevalence of tungiasis in the dry season (49%). In this study, however, inspections were conducted by school children on one another, resulting in severe intra-observer bias (Njeumi *et al*., 2002, p. 178). In our study, the same two members of the team carried out the macroscopic inspections to avoid this bias. Our study is the first comprehensive study on tungiasis and the associated morbidity in a representative sample of rural Cameroon.

It has been demonstrated that tungiasis is endemic to this region of Cameroon, and impacts heavily on the rural and agricultural communities around the town of Ndu. The parasite inhibits progress and development in the poverty stricken; farmers and other breadwinners find it more difficult to work and are held back by the associated morbidity, such as difficulty in walking, persistent itching and insomnia. From our sample, 16% found the ectoparasitosis "very debilitating", and 65% found it "quite debilitating". Even after physical removal of the flea, pain is felt for an average of 3.1 days, nevertheless 59% of the study population appeared to accept tungiasis as part of everyday life and did not consider visiting a medical centre for treatment to be worthwhile.

The distribution of prevalence by age followed a characteristic curve. It is perhaps not surprising that the recorded prevalence in children was greater than in adults since many aspects of the culture, traditions and way of life in this region place children more at risk. If worn at all, footwear seldom covers the entire foot; open shoes such as sandals and flip-flops, or indeed damaged shoes, are the most common footwear. Children are often left to play in the dry, sandy courtyard, where villagers walk through and spread the eggs of the flea (Muehlen *et al.*, 2006, p. 378). In addition, children work on the farm from a young age (the youngest farmer was 9 years old) adding even greater exposure. Adults become more proficient at detecting and eliminating a gravid female flea as they gain experience. That is, until they are hindered by the poor eyesight and reduced flexibility associated with old age. These factors offer an explanation for the S-shaped age-prevalence curve.

As the flea cannot jump very high, the host's skin must be brought close to the ground in order to facilitate access (Heukelbach, De Oliviera, Hesse, Feldmeier, 2001, p. 268). Therefore, the majority of lesions occurred on the feet, and to a lesser degree on the hands. Ectopic occurrences are significantly associated with the number of lesions, and have been observed most commonly on the elbows, thighs and gluteal region (Heukelbach *et al*., 2002, p. 215). Just 4% of the sample population reported having experienced the flea elsewhere than the hands and feet, and only one person reported experiencing the flea on their buttocks (see Case Study).

A significant difference in prevalence was observed between the sexes, much like a study in Trinidad (Chadee, 1998, p. 110). This finding, however, has not been consistent among all studies and appears to vary from one population to another. Research in Nigeria and Brazil found no statistically significant difference between the sexes (Ugbomoiko *et al*., 2007, p. 477; Muehlen *et al.*, 2007, p. 451; Ugbomoiko, Ariza, Ofoezie, Heukelbach, 2008, p. 4), while De Carvalho *et al.* observed a greater prevalence in females than in males (De Carvalho *et al*., 2003, p. 34). These data differences are likely to be related to exposure and environmental factors, rather than differences in susceptibility.

A study in North-east Brazil indicated large seasonal variation in prevalence of *Tunga penetrans*, which was greatest at the peak of the dry season (Heukelbach *et al*., 2005, p. 146). 66% of those questioned said that jigger flea infestation peaked in the dry season, and most of them (51%) placed this peak in middle of the season.

Our study has shown that tungiasis in Cameroon is a problem stretching beyond mere nuisance or irritation; it is associated with severe morbidity and is an issue which needs to be addressed. Health officials, medical doctors, churches, schools, chiefs and the sufferers themselves must all become involved if we are to tackle this disease. Numerous other studies have emphasized the need to keep animals, such as pigs and dogs, from domestic settings by containing them within an appropriate enclosure.

Intervention

Only once the true burden of a disease is known can control measures be properly implemented. The aim now is

to pioneer a low-cost poster-based education campaign portraying simple interventions to reduce the prevalence and impact of *Tunga penetrans*. Recent studies in neighbouring Nigeria (Ugbomoiko *et al*., 2007, p. 3) as well as in Brazil (Muehlen *et al*., 2006, p. 373) found a similar high prevalence of tungiasis (43% and 51% respectively), and the main associated risk factors were used in the design of our poster. Based on anecdotal evidence, our findings and the other studies, the four predominant methods for reducing tungiasis are (Joseph *et al*., 2006, p. 970; Njeumi *et al*., 2002, p. 180):

- Wearing closed shoes
- Keeping animals contained
- Watering the floors within houses regularly
- Maintaining good personal hygiene

These improvements will provide an effective approach, not only to prevent tungiasis, but also other diseases associated with poverty (Ugbomoiko *et al*., 2007, p. 479). More drastic interventions have been shown to improve the lives of tungiasis sufferers, such as concrete floors (Muehlen *et al*., 2006, p. 375; Ugbomoiko *et al*., 2007, p. 5), administering antibiotics, providing shoes (Joseph *et al*., 2006, p. 970) and also applying insecticide spray (Pilger *et al*., 2008, p. 2). Anecdotal evidence suggests that in rural villages like these, new shoes are traditionally only worn on special occasions. Providing shoes therefore would only be successful as an intervention if the shoes were worn regularly and not solely reserved for such occasions.

Conclusion

Tungiasis has been shown to be a problem for poor rural populations in numerous developing countries in South America, the Caribbean and Sub-Saharan Africa. Despite its associated morbidity and the growing awareness of the disease, however, tungiasis is not recognised on a local or international level as a serious health issue. Educating people about the risk factors and potential causes is paramount in addressing the problem. Raising awareness through a well structured poster campaign will help reduce the impact of this flea on exposed communities.

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