SEASONAL VARIATION OF TUNGIASIS IN AN ENDEMIC COMMUNITY

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Abstract. Tungiasis (caused by the sand flea Tunga penetrans) is hyperendemic in many resource-poor communities in Brazil. To understand transmission dynamics of this parasitic skin disease in a typical endemic area, a longitudinal study was carried out in a slum in Fortaleza in northeastern Brazil. In a door-to-door survey, the population of a randomly selected area (n = 1,460) was examined on four occasions for the presence of embedded sand fleas. Prevalence rates were 33.6% in March (rainy season), 23.8% in June (end of the rainy season), 54.4% in September (peak of the dry season), and 16.8% in January (begin of the rainy season). Tungiasis was more common in males than in females. The intensity of infestation was correlated with the prevalence. The study shows that prevalence of tungiasis and parasite burden vary significantly during the year with a peak in the dry season. These findings have important consequences for the design of control measures.

INTRODUCTION

Tungiasis is a parasitic skin disease caused by the female sand flea Tunga penetrans. Both the male and the female flea are hematophagous, but only the female penetrates into the skin of the host, which results in parasite hypertrophy and egg production.1 Eventually, the flea dies and is sloughed from the epidermis by tissue repair mechanisms. This process may last up to six weeks.2 If embedded fleas are not removed appropriately, lesions almost invariably become superinfected.

This ectoparasitosis occurs in many parts of Latin America, the Caribbean, and sub-Saharan Africa. In Brazil, it can be found both in northern and southern regions.1 The distribution of tungiasis is patchy, and the disease occurs predominantly in impoverished populations.3–6 In economically disadvantaged communities, the ectoparasitosis is associated with considerable morbidity.7

In the few community-based studies performed, a wide range of prevalence rates have been observed. Data available from Nigeria, Trinidad and Tobago, and Brazil suggest that between 16% and 55% of the population may be infested.8–15 Tunga penetrans parasitizes a broad spectrum of mammals. Domestic animals such as dogs, cats, and pigs are frequently affected. Peridomestic rodents such as Rattus rattus are also important reservoirs.16 It is not known to which extent the occurrence of different animal reservoirs or behavioral characteristics of the human population contribute to the highly diverging prevalence rates reported in the literature. Similar to other parasitic diseases, such discrepancies may also result if attack rates vary over time and if prevalence rates are determined during different seasons of the year. In fact, in northeastern Brazil, local residents claim that tungiasis becomes a scourge every year during the cashew nut harvest, which coincides with the dry season (September).

To validate these anecdotal observations, we examined a representative sample of the population of a typical endemic area four times during a period of 11 months, namely March (rainy season), June (end of rainy season), September (peak of dry season), and January (beginning of rainy season).

MATERIALS AND METHODS

Study area. The study was performed in Vicente Pinzón II, a typical slum (favela) in Fortaleza, the capital of Ceará State in northeastern Brazil. The area is close to the beach and has a total population of approximately 15,000 inhabitants. Two-thirds of the households have access to piped water. Sixty percent of the population have a monthly family income of less than two minimum wages (1 minimum wage = $80). The adult illiteracy rate is 30% and unemployment rates are high.17 Many houses are made of recycled materials and do not have cemented floors. Roads and paths are not paved. Waste collection is performed merely at the boundaries of the slum, and garbage of all sorts is scattered throughout the area. There is no public sewage system and hygienic conditions are precarious. There are innumerable stray dogs and cats, and many families keep dogs and cats as companion animals. The study area is comparable to the many other favelas in northeastern Brazil.

According to observations of the physicians of the local Primary Health Care Center, three sub-areas of the township (Antônio Carneiro, Luxou, and Morro de Sandra’s) are high-risk areas for parasitic skin diseases such as cutaneous larva migrans, scabies, pediculosis, and tungiasis. The sub-area Morro de Sandra’s was selected for this study by randomization.

Study design. In March 2001, Morro de Sandra’s was inhabited by 1,460 individuals belonging to 327 households (mean = 4.5, range = 1–13 individuals/household). A door-to-door survey was carried out in March 2001, and all households were again visited in June 2001, September 2001, and January 2002. The time schedule was planned such that one survey was performed in the rainy season (March), another at the end of the rainy season (June), the third in the peak of the dry season (September), and the final one in the beginning of the rainy season (January).

To reduce inter-observer bias, all clinical examinations were performed by the same investigator (TW). In case of absent family members, the households were revisited twice. For safety reasons, the examinations were restricted to between 7:00 AM and 5:30 PM, i.e., during full daylight.

Clinical examination and case definition. Each member of the household was examined thoroughly. Since ectopic lesions are easily overlooked, special attention was paid to unusual sites of infestation with T. penetrans.18 The diagnosis of tungiasis was made by clinical inspection of the lesions according to the Fortaleza Classification.7 Briefly, the diagnosis was based on the presence of a red-brown itching spot with a
diameter of 1–2 mm (early stage), the presence of a yellow-white watch-glass-like patch with a diameter of 3–10 mm with a central dark spot (mature stage), and a brown-black crust with or without surrounding necrosis (dead flea = late stage).

Embedded sand fleas with evidence of manipulation by the patient or his or her caretaker with instruments such as needles or thorns was also documented. Such lesions leave a characteristic crater-like sore in the skin.2

Data analysis. Data were entered twice into a database using Epi-Info version 6.04d software (Centers for Disease Control and Prevention, Atlanta, GA) and checked for errors that might have occurred during their entry. Ninety-five confidence intervals of prevalence rates were calculated using the respective Epi-Info modules. The chi-square test was used to determine the differences of relative frequencies. Correlations were determined using STATA™ version 7 software (Stata Corporation, College Station, TX). To compare the parasite burden between surveys, the Wilcoxon signed rank test was used.

Monthly precipitation and temperature data for the Fortaleza Municipality were obtained from the Meteorologic Foundation of Ceará State (Fundação Cearense de Meteorologia, Fortaleza, Brazil).

Ethical considerations. Permission to perform the study was obtained from the Health Authority of Fortaleza Municipality. Community associations of the township (associações dos moradores) gave their consent to the study. Prior to the study, meetings with community health workers and community leaders were held and the objectives were explained. Informed oral consent was obtained from all adult participants and from the parents or legal guardians of minors. At the end of the study, all participants were treated for tungiasis by standard therapy (removing the embedded flea with a sterile needle and disinfection of the skin lesion). Other parasitic skin diseases diagnosed during the surveys such as scabies, cutaneous larva migrans, and pediculosis were also treated.

RESULTS

During the first door-to-door survey, 1,185 individuals (81.2%) of the total population were examined. They belonged to 301 (92.1%) of the 327 existing households in the study area. The number of individuals examined at each survey, the number of males and females examined, and the number of individuals examined > 15 years old and ≤ 15 years old are shown in Table 1.

Consistently, more females than males and more children than adults participated in the study. The lowest proportions of the target population were examined in September 2001 (58.2%) and January 2002 (60.8%). At the peak of the dry season (September) many inhabitants of the community frequented nearby beaches, and during the holiday season (January) many adults work as hawkers (peddlers) in the tourist areas.

The age-specific prevalence rates are shown in Table 2. In all surveys, children 5–9 years of age had the highest prevalence rates. Tungiasis was more common in males than in females (P < 0.001 for March, June and September and P < 0.05 for January) (Figure 1). The disease showed considerable seasonal variation, with the prevalence being highest at the peak of the dry season (September, 54.4%) and lowest after the first rain of the rainy season (January, 16.8%). Overall prevalence rates differed significantly between all surveys and for all possible data pairs (P < 0.001 in all cases). The seasonal variation was paralleled by similar variation of age-specific prevalence rates.

Figure 2 shows the variation of overall prevalence rates of tungiasis and the monthly precipitation in the study period. The prevalence started to increase with drier weather and peaked when precipitation was zero. Thereafter, the prevalence decreased when it started raining again at the end of the year.

There was a significant difference in the number of lesions per individual between the different surveys (P < 0.001 in all cases) (Table 3). The mean parasite burden was positively correlated with the prevalence (r = 0.81, P = 0.01) (Figure 3).

The monthly mean temperature varied little from 25.7°C in July to 27.3°C in January/December and showed no association with tungiasis prevalence.

DISCUSSION

Tungiasis has been a common disease in many parts of Latin America and the Caribbean for many years. This is reflected by the innumerable popular names for the ectoparasitosis, such as nigua (Argentina, Venezuela, and the Caribbean), kuti, suthi-pique (Bolivia), ogri eye (Surinam), bicho de pé, bicho de porco (Brazil), chica (Colombia and Venezuela), sikka (Guyana), pique (Argentina, Chile, Uruguay, and Paraguay), piqui (quêchua), and tã (tupi guarani).1,19 It remains unclear whether socioeconomic changes have led to a decrease of occurrence of the ectoparasitosis since the 1970s, or whether it became neglected as a disease entity associated with extreme poverty.1 In Brazil, infestation by T. penetrans is still common in economically disadvantaged communities, ur-
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Table 2
Age-specific point prevalences of tungiasis at the four surveys and 95% confidence intervals (CIs)

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<tr>
<td></td>
<td>Prevalence (95% CI)</td>
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<tr>
<td>0–4</td>
<td>40.7% (34.6–47.1)</td>
<td>33.8% (27.6–40.4)</td>
<td>67.8% (60.4–74.5)</td>
<td>32.6% (25.6–40.1)</td>
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<tr>
<td>5–9</td>
<td>56.5% (48.7–64.2)</td>
<td>41.3% (33.8–49.0)</td>
<td>72.8% (64.5–80.1)</td>
<td>31.4% (23.9–39.8)</td>
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<td>10–14</td>
<td>44.6% (37.2–52.5)</td>
<td>31.2% (24.4–38.7)</td>
<td>64.4% (55.6–72.5)</td>
<td>21.7% (14.7–30.1)</td>
</tr>
<tr>
<td>15–19</td>
<td>23.0% (16.0–31.4)</td>
<td>16.3% (12.0–20.7)</td>
<td>43.9% (33.0–55.5)</td>
<td>7.5% (2.8–15.6)</td>
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<tr>
<td>20–29</td>
<td>16.5% (12.6–21.3)</td>
<td>9.5% (6.7–13.2)</td>
<td>34.4% (28.1–41.2)</td>
<td>2.9% (1.2–5.8)</td>
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<tr>
<td>30–39</td>
<td>23.7% (16.2–32.6)</td>
<td>16.2% (10.1–24.2)</td>
<td>41.8% (30.8–53.4)</td>
<td>6.2% (2.3–13.0)</td>
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<tr>
<td>≥ 40</td>
<td>38.1% (23.6–54.4)</td>
<td>27.0% (13.8–41.1)</td>
<td>52.0% (31.3–72.2)</td>
<td>11.4% (3.2–26.7)</td>
</tr>
<tr>
<td>Total</td>
<td>33.6% (30.9–36.4)</td>
<td>23.8% (21.4–26.3)</td>
<td>54.4% (51.0–57.8)</td>
<td>16.8% (14.4–19.4)</td>
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Figure 1. Point prevalence rates of tungiasis in an endemic area in northeastern Brazil stratified by sex. Error bars show 95% confidence intervals.

Figure 2. Seasonal variation of the prevalence of tungiasis and monthly precipitation from January 2001 to January 2002 in Fortaleza, northeastern Brazil. Error bars show 95% confidence intervals.
We therefore suggest that seasonal variation of prevalence and infestation intensity indicates changes in the dynamics of the flea population that are related to climatic variables. Conceivably, high humidity in the soil impairs the development of free-living stages of *T. penetrans*. Furthermore, heavy rains may simply wash away eggs, larvae, pupae, nymphs, and adults. Interestingly, in rural communities in Ceará, the local population irrigates the soil of their compounds to reduce attack rates.

We cannot rule out that bias due to non-participation, especially in the September and January surveys when only 58% and 61% of the target population were examined, contributed to differences in prevalence. Since adult males, the subgroup with the lowest prevalence of tungiasis, were consistently under-represented (many male adults are absent from the favela during daytime, and for safety reasons the examination were not carried out during darkness), the true population prevalence might actually be lower than reported.

The varying attack rates of *T. penetrans* during the year help to explain the highly diverging prevalence rates observed in previous studies. In fact, a closer look into the studies published confirmed that they were performed at different seasons of the year over a prolonged period of time, and that period rather than point prevalence rates were assessed.\(^8\,15\,20\,22\) Obviously, if one aims to determine the occurrence of a disease that is subject to seasonal variation, cross-sectional studies do not allow conclusions to be made on the health impact of the respective disease in the area.

Variation of prevalence correlated significantly with infestation intensity. Since the parasite load is directly responsible for the degree of tungiasis-associated morbidity, assumably morbidity will also vary during the year. Control measures aimed at reducing morbidity should then be scheduled to be in place before the attack rate increases, i.e., at the beginning of the dry season, and focused on the most vulnerable population groups, namely children and the elderly.

An ancillary finding of our study is the observation that tungiasis was consistently more common in males. This confirms less convincing data from previous studies and indicates different exposure of males and females to *T. penetrans*.\(^9\,10\,12\,22\)

Recently, a second sand flea species from Ecuador (*Tunga trimamillata*) parasitizing humans has been identified.\(^23\,24\) Epidemiologic features of this new species are unknown, and it cannot be excluded that this species is also endemic in northeast Brazil.

In summary, we have performed the first longitudinal study on tungiasis and have shown for the first time that infestation follows a characteristic seasonal variation. Prevalence was highest in the dry season, decreased dramatically with the start of the rainy season, and was related to infestation intensity. The data suggest scheduling intervention measures at the beginning of the dry season to prevent severe morbidity.

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