SHORT REPORT: INFESTATION OF WISTAR RATS WITH TUNGA PENETRANS IN DIFFERENT MICROENVIRONMENTS

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Abstract. Tungiasis is a zoonotic ectoparasitosis that causes considerable morbidity in affected populations. The type of microenvironment that facilitates infestation of hosts by Tunga penetrans has not been investigated. In this study, we exposed 30 laboratory-raised Wistar rats, a suitable model for the infestation, at six different places characterized by different microenvironments in a hyperendemic fishing village in northeastern Brazil. During a period of two weeks, the animals were monitored and the number of embedded fleas was documented. The number of lesions varied considerably according to the microenvironment and was highest in a cage placed at the far end of a compound of a household affected by tungiasis. No penetration was observed inside houses. Results indicate that in this endemic area transmission of T. penetrans seems to occur mainly outdoors.

Tungiasis is a parasitic skin disease caused by the penetration of the female sand flea (Tunga penetrans) into the epidermis of its host. The zoonosis is widespread in resource-poor urban and rural communities in sub-Saharan Africa, the Caribbean region, and South America.1 Tunga penetrans infests a broad range of sylvatic, domestic, and pet animals, such as monkeys, cows, pigs, goats, cats, and dogs.2–7 In addition, at least in northeastern Brazil, Rattus rattus has been frequently found to be infested.3 Because of the zoonotic characteristics of this ectoparasitosis, it is difficult to establish the role various animal reservoirs have on human infestation. It is assumed that different animal species contribute to the spread of the parasite in a complex manner that depends on the environmental, social, and economic characteristics of a disease-endemic area. For example, in an urban squatter settlement in Brazil, dogs, cats, and R. rattus were identified as the most important reservoirs, with 67%, 50%, and 42% of the animal species, respectively, being infested.3

The older literature has many anecdotal reports suggesting that newcomers to a disease-endemic village got heavily infested, usually at night, when they stayed in shelters used by animals, abandoned huts, or houses not well maintained in which organic waste littered the soil.8,9 These shelters did not have solid floors, doors and windows, if any, were kept open so that domestic animals could freely move in and out. Roofs were not tight, which allowed rodents to enter at night. Obviously, these circumstances would facilitate the establishment of an intradomiciliary life cycle of T. penetrans, even in the absence of inhabitants. However, whether infestation actually occurs indoors has never been properly investigated. A recent study indicated that housing and the characteristics of a disease-endemic area. For example, in an urban squatter settlement in Brazil, dogs, cats, and R. rattus were identified as the most important reservoirs, with 67%, 50%, and 42% of the animal species, respectively, being infested.3

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The rats were examined every 24 hours for newly embedded sand fleas. In Wistar rats, T. penetrans only penetrates the foot pad, phalanges, and tail; only these topographic areas were examined (Witt L, unpublished data). At each examination, the number of embedded sand fleas and their topographic location was entered on a record sheet. After 14 days of observation, the experiment was ended and infested animals were humanely killed with ether. Ethical approval for the study was obtained from the Ethical Committee at the Federal University of Ceará, Brazil.
Three to four days after eggs have been shed, the first instar larva develops and starts to feed on organic material present in soil. In contrast to other flea species, T. penetrans has only two larval stages and one nymphal stage. Pupae develop into adults approximately 18 days after eggs have reached a suitable place for development. The physical and chemical characteristics of soil needed for successful completion of the off-host part of the life cycle of T. penetrans are not well known. However, circumstantial evidence indicates that dry soil containing organic material such as household detritus or decaying leaves is an excellent habitat for the parasite.

A risk factor study performed in the village showed a fourfold increased risk for the presence of tungiasis in households when the house was constructed from crude adobe or palm stems and an eight-fold increase for houses with a floor consisting of sand. This also points to the importance of a particular micro-environment for the transmission of T. penetrans and could indicate indoor transmission. However, indoor transmission was not observed in this study, although the small number of experiments does not allow a definitive conclusion. If transmission mainly occurs outdoors, this has important implications for preventive measures. It would be appropriate to spray the ground with a contact insecticide where pets frequently rest, but it would not be reasonable to spray the floors of houses.

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### Table 1

<table>
<thead>
<tr>
<th>Cage designation</th>
<th>Location</th>
<th>Intensity of sunshine</th>
<th>Organic waste present on soil</th>
<th>Domestic animals present</th>
<th>No. of household members</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Inside (living room)</td>
<td>Shadow</td>
<td>No</td>
<td>None</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>Inside (kitchen)</td>
<td>Shadow</td>
<td>Little</td>
<td>Cat, chicken</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>Outside, near housewall</td>
<td>Shadow</td>
<td>Moderate</td>
<td>Cat, chicken</td>
<td>6</td>
</tr>
<tr>
<td>D</td>
<td>Outside, open kitchen stall</td>
<td>Shadow</td>
<td>Much</td>
<td>Cat, chicken</td>
<td>6</td>
</tr>
<tr>
<td>E</td>
<td>Under mango tree</td>
<td>Half shadow</td>
<td>Little</td>
<td>Dog, cat, chicken</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>Rear part of compound</td>
<td>Half shadow</td>
<td>Moderate</td>
<td>Dog, chicken</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 2

Penetration of Tunga penetrans in Wistar rats exposed in different micro-environments

<table>
<thead>
<tr>
<th>Cage designation</th>
<th>Location</th>
<th>No. of rats exposed</th>
<th>Rats infested no. (%)</th>
<th>Successfully embedded sand fleas</th>
<th>Lesions per rat median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Inside (living room)</td>
<td>5</td>
<td>0 (0)</td>
<td>0</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>B</td>
<td>Inside (kitchen)</td>
<td>4</td>
<td>0 (0)</td>
<td>0</td>
<td>0 (0–0)</td>
</tr>
<tr>
<td>C</td>
<td>Outside, near housewall</td>
<td>5</td>
<td>2 (40)</td>
<td>2</td>
<td>0 (0–1)</td>
</tr>
<tr>
<td>D</td>
<td>Outside, open kitchen stall</td>
<td>5</td>
<td>4 (80)</td>
<td>11</td>
<td>1 (0–7)</td>
</tr>
<tr>
<td>E</td>
<td>Under mango tree</td>
<td>6</td>
<td>5 (83)</td>
<td>11</td>
<td>2 (0–3)</td>
</tr>
<tr>
<td>F</td>
<td>Rear part of compound</td>
<td>5</td>
<td>5 (100)</td>
<td>48</td>
<td>7 (4–17)</td>
</tr>
</tbody>
</table>
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