Risk factors for reinvasion of human dwellings by sylvatic triatomines in northern Bahia State, Brazil

Fatores de risco para re-infestação de domicílios por triatomíneos silváticos no norte do Estado da Bahia

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Abstract

The aim of this study in Curaça, Bahia, Northeast Brazil was to explore possible factors associated with the infestation of human dwellings by Triatoma brasiliensis *or* Triatoma pseudomaculata*, two sylvatic triatomine species. We use multiple logistic regression analysis to show how structural features of the peridomiciliary area combine with the number of animals and sociological factors to allow infestation of some dwellings. It is suggested that* T. brasiliensis *is associated with human activities, while* T. pseudomaculata *is associated with vegetation and animals. Peridomiciliary farm animals are a strong risk factor for triatomine infestation.*

Triatominae; Risk Factors; Vector Control

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Introduction

In Northeast Brazil, the main vectors for American trypanosomiasis are currently *Triatoma brasiliensis* and *Triatoma pseudomaculata*, two widely distributed native species. They are captured in domiciliary and peridomiciliary areas which they reinvade from natural ecotopes [1]. The potential for re-infestation of peridomiciliary annexes is high [2]. Both of these vectors lodge in corral fences, chicken coops, and piles of various materials found in and around numerous buildings in this farming and livestock area [3,4,5]. However, the joint effects of peridomiciliary structural features, the number of synanthropic animals, and sociological factors on domiciliary infestation are still not well known.

In order to broaden the knowledge on risk factors for peridomiciliary re-infestation by sylvatic triatomines, the objective of this study was to assess the main characteristics of dwellings (environmental, demographic, and socioeconomic factors are the independent variables) associated with *T. brasiliensis* or *T. pseudomaculata* infestation. We use multiple logistic regression analysis to investigate variations among domiciliary units in terms of the likelihood of being infested by triatomines.

Material and methods

Study area

Field studies were conducted in Curaça, a northern rural municipality (county) in Bahia State devoted to goat and sheep raising and irrigated agriculture. Phytogeographically, the area belongs to the *caatinga* (scrub forest) region. The study area has three main geographic zones with the following characteristics: (a) irrigated agriculture, near the São Francisco River, (b) livestock raising with altered vegetation due to heavy anthropic pressure, and (c) more preserved vegetation and more scattered human dwellings. In 2000, after three years of negative capture, *T. infestans* was considered to have been eliminated from Curaça.

From September to November 2002, 136 randomly plotted houses were visited and georeferenced using GPS. Data collection used a standard questionnaire submitted to each household member, a sketched map of each house and peridomiciliary annexes, and an entomological survey (bug capture and analysis). The peridomicile, as defined in this paper, is the yard supporting peridomiciliary structures, regardless of the distance from the main house. Data were computerized as nominal variables (2 to 4 classes) or continuous variables. *Environmental data* relate to the general situation and spatial organization of the domiciliary unit; *demographic data* to the number of human inhabitants and synanthropic animals (dogs, livestock, and poultry), *sociological data* to the origin of the household members, duration of residence, ownership of house (yes/no), head of family retired (yes/no), and use of insecticides (yes/no).

Associations between domiciliary infestation and continuous and nominal variables were first tested by the Mann-Whitney test and Fisher's exact test. Independent variables that were associated with a p-value of 10% or less were selected for multivariate logistic regression analysis. Variables without significant adjusted effect (likelihood ratio statistic, p-value > 0.05) were eliminated from the model according to a backward stepwise procedure. Introduction of the previously dropped variables into the most parsimonious model was then tested one-by-one by likelihood ratio statistic. Finally, only significant independent variables (p-value < 0.05) were kept in the model.

Results

A total of 395 bugs (73 *T. pseudomaculata* and 322 *T. brasiliensis*) were captured, in 50.0% of the domiciliary units (68/136). *T. brasiliensis* was present in 36.8% (50/136) and *T. pseudomaculata* in 18.4% (25/136). *T. brasiliensis* was mainly captured in corral fences (31.2% of the 80 capture sites), piles of tiles or bricks (12.5%), and chicken coops (10.0%), as compared to *T. pseudomaculata* in corral fences (45.9%) and trees used as chicken roosts (48.0%).

Table 1 shows the significant correlations between infested dwellings and descriptive variables. Dwelling infestation rates for *T. brasiliensis* were positively and significantly associated with mud or adobe houses, number of corrals, *mandacaru* cactus within a 30m radius of the house, and local origin of the household members, and non-significantly with geographic location of the house in the altered vegetation zone. The rates did not increase with numbers of animals, whatever the species. However, the absence of goats and sheep was associated (non-significantly) with low infestation rates in dwellings (1/10, 10.0%), while a herd of 20-99 goats or sheep was associated with a higher infestation rate (23/41, 48.8%).

Dwelling infestation rates with *T. pseudomaculata* were positively and significantly associated with the geographic location of the house (surroundings with more vegetation), surface area of the domiciliary unit, presence of adobe houses, number of corrals, corral surface area, type of chicken roosts (trees), and head-of-household's retirement. The rates increased positively and significantly with the numbers of all synanthropic animals: dogs ($p = 0.0003$), goats or sheep ($p = 0.0001$), cattle ($p = 0.0001$), and poultry ($p = 0.0054$).

Triatomine infestation (*T. brasiliensis* and *T. pseudomaculata* combined) was significantly associated with kerosene lamp lighting and solar panel lighting ($p = 0.019$).

According to multiple logistic regression analysis (Table 2), the likelihood of infestation with *T. brasiliensis* increased with local origin of the household members, presence of goats and sheep, presence of corrals, and presence of *mandacaru* cactus within a 30m radius of the house. The likelihood of *T. pseudomaculata* infestation increased with the house being located near relatively preserved vegetation, head-of-household's retirement, presence of at least two dogs or five cows, and large corrals.

Table 1

Environmental and socioeconomic variables associated with *Triatoma brasiliensis* and *Triatoma pseudomaculata* infestation.

Variables	Number of domiciliary units visited	Domiciliary unit infestation					
		Triatoma brasiliensis			*Triatoma pseudomaculata*		
		Number	%	p-value	Number	%	p-value
Area							
Near river	33	9	27.27	0.152	1	3.03	< 0.001
Altered	44	21	47.73		4	9.09	
Dense vegetation	59	20	33.30		19	32.20	
Surface area of domiciliary unit (m²)							
< 2,000	60	19	31.66	0.456	6	10.00	0.012
2,000-5,000	59	23	38.98		12	20.33	
≥ 5,000	17	8	47.05		7	41.17	
Building material of walls in human dwellings							
Mud and wattle	37	16	43.24	0.011	2	5.41	0.039
Adobe	53	22	41.51		14	26.42	
Local fired brick	32	12	37.50		5	15.60	
Modern masonry	14	0	0.00		4	28.60	
Number of corrals							
0	14	3	21.42	0.0307	0	0.00	0.005
1-2	45	13	28.88		3	6.66	
3-4	44	15	34.09		13	29.54	
≥ 5	33	19	57.57		9	27.27	
Surface area, corrals (m²)							
< 150	44	13	29.50	0.248	3	6.80	0.009
150-550	52	24	46.00		13	25.00	
≥ 550	25	10	40.00		9	36.00	
Length of fence (m)							
< 80	57	18	31.57	0.165	4	7.01	0.0007
80-200	53	23	43.39		16	30.18	
≥ 200	10	06	60.00		5	50.00	
Chicken coops							
None	17	7	41.18	0.366	1	5.88	0.023
Roosts in trees	92	33	35.86		23	25.00	
Other kind	25	10	40.00		1	4.00	
Mandacaru cactus within 30m of house							
No	83	25	30.12	0.044	14	16.86	0.568
Yes	53	25	47.17		11	20.75	
Head of household retired							
No	77	32	41.56	0.212	9	11.69	0.026
Yes	59	18	30.51		16	27.12	

Note: Domiciliary unit defined as area encompassing house and outbuildings.

Discussion and conclusions

The county of Curaça illustrates an epidemiological situation with: (i) stable population and economic activities, (ii) *T. infestans* eliminated, and (iii) sylvatic vectors (*T. brasiliensis* and *T. pseudomaculata*) well-established in peridomiciliary areas. This study confirms previous findings on peridomiciliary habitats of *T. brasiliensis* and *T. pseudomaculata* [6,7,8] and shows that *T. pseudomaculata* is more associated with environmental characteristics and animals, while *T. brasiliensis* is associated with peridomiciliary structures and human activities. Moreover, it suggests some risk factors for domiciliary infestation.

First, the dwelling's type of environment is a risk factor. Domiciliary infestation with *T. pseudomaculata* increases (OR = 17) when the house is built in preserved vegetation where natural ecotopes of the species such as bird nests, tree hollows, and palms [9,10,11] are more numerous. Farmers often mention that the bugs are attracted by light, suggesting a regular flow of sylvatic vectors towards peridomiciliary areas. Dwellings located in areas with altered vegetation and submitted to heavy anthropic pressure are more frequently infested with *T. brasiliensis*. *Mandacaru*, a cactus grown around farms to complement livestock feed, is an indicator of an active livestock activity in an impoverished environment. It is also significantly associated with *T. brasiliensis* infestation.

Second, human activities play an important role in domiciliary infestation. Origin, age, and retirement of household members were included as possible indicators of the farm families' general way of life. They are associated with *T. brasiliensis* and *T. pseudomaculata* infestation, probably through different activities and different ways of managing peridomiciliary areas and animals.

Third, the results suggest that presence of livestock produces numerous interconnected risk factors for triatomine infestation. Corrals and livestock are strongly correlated with infestation of human dwellings. It is thus probable that the general conditions under which livestock are raised should be better researched and improved to obtain optimum triatomine control.

In this context, where adaptation of vectors to the natural environment and human activities has occurred for a long time, triatomine infestation of human dwellings is obviously a multi-factor process which should to be studied as such.

Table 2

Odds ratio between infestation of domiciliary unit with *Triatoma brasiliensis* or *Triatoma pseudomaculata* and socioeconomic, environmental, and demographic variables (multivariate analysis).

Species	Odds ratio	95%CI	p-value
Triatoma brasiliensis			
Origin of household members			
Other municipality	1.0	–	0.005
Same municipality	4.4	1.6-12.5	
Goat/sheep			
Absence	1.0		0.008
< 100	13.2	1.1-167.9	
≥ 100	3.2	0.3-39.7	
Corrals			
No	1.0		< 0.001
Yes	3.1	1.1-8.3	
Mandacaru cactus within 30m of house			
No	1.0		0.050
Yes	2.2	1.1-8.3	
Triatoma pseudomaculata			
Geographic area			
River and altered	1.0		< 0.001
More dense vegetation	17.1	3.9-75.6	
Head of household retired			
No	1.0		0.008
Yes	5.8	1.6-21.4	
Dogs			
< 2	1.0		0.002
≥ 2	12.8	2.6-63.3	
Cattle			
< 5	1.0		0.014
≥ 5	6.0	1.4-24.8	
Corral surface area (m^2)	1.0024	1.0002-1.0046	0.030

Resumo

O objetivo deste estudo foi o de explorar (em Curaçá, município do Estado da Bahia, no Nordeste brasileiro) os possíveis fatores associados à infestação das moradias pelo Triatoma brasiliensis *ou* Triatoma pseudomaculata, *dois triatomas das espécies silvestres. Usamos uma análise "logística" de múltipla regressão para mostrar como as características estruturais da área do peridomicílio associadas ao número de animais e a fatores sociológicos favorecem a infestação em algumas moradias. Isso sugere que* T. brasilienses *está associado às atividades humanas enquanto* T. pseudomaculata *está associado à vegetação e aos animais. Assim, o manejo da pecuária é um importante fator de risco para a infestação de triatomíneos.*

Triatominae; Fatores de Risco; Controle de Vetores.

Contributors

A. Walter, I. Pojo do Rego, A. Ferreira and C. Rogier participated in the overall study concept and design, data collection, data analysis, and drafting of the paper.

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References

1. Dias JC. Controle de vetores da doença de Chagas no Brasil e riscos da reinvasão domiciliar por vetores secundários. Mem Inst Oswaldo Cruz 1988; 83 Suppl 1:387-91.
2. Diotaiuti L, Faria Filho OF, Carneiro FC, Pinto-Dias JC, Pires HH, Schofield CJ. Aspectos operacionais do controle do *Triatoma brasiliensis*. Cad Saúde Pública 2000; 16 Suppl 2:61-7.
3. Lucena D. Ecologia dos triatomineos do Brasil. Rev Bras Malariol Doenças Trop 1959; 11:577-635.
4. Lucena D. Doença de Chagas no nordeste. Rev Bras Malariol Doenças Trop 1959; 11:675-96.
5. Costa J, Almeidan JR, Britton C, Duarte R, Marchon-Silva V, Pacheco RD. Ecotopes, natural infection and trophic resources of *Triatoma brasiliensis* (Hemiptera, Reduviidae, Triatominae). Mem Inst Oswaldo Cruz 1998; 93:7-13.
6. Oliveira-Lima JW, Faria Filho OF, Furtado-Vieira JB, Vieira-Gadelha F, Oliveira Filho AM. Alterações do peridomicílio e suas implicações para o controle do *Triatoma brasiliensis*. Cad Saúde Pública 2000; 16 Suppl 2:75-81.
7. Silveira AC, Costa-Vinhaes M, Lira E, Araujo E. O controle de *Triatoma brasiliensis* e *Triatoma pseudomaculata*. II. Avaliação do controle físico, pela melhoria habitacional, e caracterização do ambiente peridomiciliar mais e menos favorável à persistência da infestação ou reinfestação por *Triatoma brasiliensis* e *Triatoma pseudomaculata*. Brasília: Organização Pan-Americana da Saúde; 1998.
8. Torquato GN, Santos CC, Mendonça MB, Carvalho SM, Kido EA, Santos ES, et al. Eco-epidemiology of Chagas disease in Pernambuco: I. present role of wild triatomines in the transmission of *Trypanosoma cruzi*. Mem Inst Oswaldo Cruz 1998; 93 Suppl 2:331.
9. Alencar JE. História natural da doença de Chagas no Estado do Ceará. Fortaleza: Imprensa Universitária, Universidade Federal do Ceará; 1987.
10. Bento ON, Freitas MR, Pinto A. Epidemiologia da doença de Chagas nos municípios de Castelo do Piaui e Pedro II, Estado do Piauí, Brasil. Rev Bras Malariol Doenças Trop 1989; 22:73-9.
11. Mello DA. Aspectos do ciclo silvestre do *T. cruzi* em regiões de cerrado (município de Formosa, Estado de Goiás). Mem Inst Oswaldo Cruz 1981; 76:227-46.

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