Spatial distribution of triatomine bugs in a Chagas disease endemic region in Brazil

Tatiene Rossana Móta Silva[1], Guilherme Mota Maciel do Rêgo Barros[2], Thiago Antonio Rodrigues Freire Lima[3], Alessio Giannelli[4], Gesika Maria da Silva[1,5], Karla Michelle de Lima Alves[5], Gilcia Aparecida de Carvalho[2] and Rafael Antonio Nascimento Ramos[2]

[1]. Programa de Pós-Graduação Stricto Sensu em Ciência Animal Tropical, Universidade Federal Rural de Pernambuco, Recife, PE, Brasil.
[2]. Unidade Acadêmica de Garanhuns, Universidade Federal Rural de Pernambuco, Garanhuns, PE, Brasil.
[3]. Departamento de Engenharia Cartográfica, Universidade Federal de Pernambuco, Recife, PE, Brasil.
[4]. Poulpharm BVBA, Izegem, Belgium.
[5]. V Gerência Regional de Saúde, Secretaria Estadual de Saúde, Garanhuns, PE, Brasil.

Abstract

Introduction: *Trypanosoma cruzi* is the etiological agent of Chagas disease (CD), a zoonotic infection transmitted by triatomine bug vectors to human beings. Although the story of this parasitic infection was born in Brazil and here this has made major step forward information, the same cannot be said about the actual distribution of the triatomine vector in several areas of this country. The aim of this study was to assess the occurrence of triatomine species in an endemic region for CD in Northeastern Brazil. Methods: A retrospective study was performed using data obtained from 2008 to 2017. All information was provided by the V Gerência Regional de Saúde of the state of Pernambuco. The spatial distribution of triatomine species was analyzed by drawing a map using the Quantum geographic information system. Results: A total of 4,694 triatomine specimens (469.4 ± 221.2 per year) were collected during the period 2008-2017, with 94.5% (4,434/4,694) at the intradomicile and 5.5% (260/4,694) at peridomicile environment. Of all arthropods collected, 92.5% (4,340/4,694) and 7.5% (354/4,694) were adults and nymphs, respectively. The species most frequently detected were *Panstrongylus lutzi* (30.36%), *Triatoma brasiliensis* (26.12%), *Triatoma pseudomaculata* (22.43%), and *Panstrongylus megistus* (20.54%). Conclusions: These data contribute to a better understanding of the distribution of *T. cruzi* infection in the Northeastern region of Brazil. Preventive measures based on vector control should be implemented in the study area in order to reduce the burden this neglected tropical disease.

Keywords: Vector. American trypanosomiasis. Epidemiology. Brazil.

INTRODUCTION

*Trypanosoma cruzi* (Kinetoplastida: Trypanosomatidae) is acknowledged as the etiological agent of Chagas disease (CD). This parasitic infection is currently considered as one of the most important neglected tropical diseases and is a major threat to public health, with an annual incidence of 28,000 cases and up to 12,000 deaths in the Americas alone[1]. The transmission of the CD relies on occurrence of triatomine vectors (e.g., *Triatoma infestans*, *Panstrongylus megistus* and *Rhodnius robustus*) that carry the infecting form of the protozoon (i.e., metacyclic trypomastigotes) in their fecal fluids, which are detected near the site of the bite wound after a blood meal. Alternatively, *T. cruzi* comes into contact with vertebrate hosts through intact mucosal membranes, such as the conjunctiva[2]. Furthermore, in recent years additional routes of transmission such as blood transfusion, organ transplantation, and transplacental and oral transmission have acquired importance[3].

The vectors of *T. cruzi* are hematophagous insects (Reduviidae: Triatominae) belonging to a group of 148 species, 65 of which occur in Brazil[4]. Approximately ten species are epidemiologically important for the transmission of CD[5]. In Brazil, the presence of these reduvids has been
reported in different regions, since they are adapted to distinct ecotypes\(^5,6\). These specimens may live in intradomiciliary and peridomiciliary environments\(^7,8\). Peridomiciliary ecotypes, including animal facilities and building remains, play an important role as a bridge between the domestic and wild cycles of the disease\(^8,9\).

Only a few epidemiological surveys have been conducted in distinct Brazilian regions so far. For instance, in the Southeast region, \(P. \text{megistus}\) has been retrieved in urban areas\(^10\), while in the South Brazil, \(T. \text{circumcincta}\) and \(T. \text{rubrovaria}\)\(^11\) have been reported as the most commonly detected species. In the Northeast region species such as \(T. \text{brasiliensis}\), \(P. \text{lutzi}\) and \(T. \text{pseudomaculata}\) are frequently reported\(^7,9,12\). It is important to note that several natural environments in this region (e.g., xerophilous trees and rocks) are inhabited by triatomines\(^13\).

Data on the distribution of these vectors is needed to better understand the epidemiological aspects related to the transmission of CD and to drive preventive interventions\(^7\). Therefore, the aim of this study was to assess the occurrence and distribution of triatomine species in an endemic region for CD in Northeastern Brazil.

**METHODS**

**Study area**

The study was conducted in the microregion of Garanhuns (Latitude 8°53′27″ South and Longitude 36°29′48″ West), state of Pernambuco, Northeastern Brazil (Figure 1). The area includes 21 municipalities, and it is featured by a semi-arid climate with a mean annual temperature of 22°C (17 - 30°C), mean annual rainfall of 147 mm (25 - 295 mm), and relative air humidity of 90%.

From 2007 to 2015, 773 cases of CD were recorded in the study area, with an annual average of 85.8 cases per year\(^14\).

**Study design and data analysis**

A retrospective study was performed using data obtained from 2008 to 2017. All data were provided by the 5ª Gerência Regional de Saúde of the state of Pernambuco, and were taken from the National Chagas Disease Control Program.

Information about vector species, life stage, area of capture, and municipality were obtained, and the absolute and relative frequencies were calculated. In addition, the Chi-square test (\(\chi^2\)) with Yates correction (5% significance level) was used to compare the positivity between species and area of capture (intradomicile or peridomicile), and between stages and area of capture. The BioEstat software (version 5.3) was used for these analyses\(^15\).

The spatial distribution of triatomine species were analyzed by drawing a map using the Quantum geographic information system (QGIS 3.2 BONN). The Jenks optimization method was used to organize the data, and subsequently construct a histogram of frequencies to identify clustering\(^16\).

**RESULTS**

A total of 4,694 triatomine specimens (469.4 ± 221.2 per year) were collected during the study period, with 94.5% (4,434/4,694) and 5.5% (260/4,694) from the intradomiciliary- and peridomiciliary- environments, respectively. A highly significant difference was observed between the most common species and area of capture (\(\chi^2 = 50.363; p = 0.0000\)), and between life stages and area of capture (\(\chi^2 = 112.496; p = 0.0000\)). The largest number of specimens collected in a single year (17.3%; 870/4,694) was obtained during 2008. Of all invertebrates collected 92.5% (4,340/4,694) and 7.5% (354/4,694) were adults and nymphs, respectively (Table 1). The reduviid species most frequently reported were \(P. \text{lutzi}\) (30.36%), \(T. \text{brasiliensis}\) (26.12%), \(T. \text{pseudomaculata}\) (22.43%), and \(P. \text{megistus}\) (20.54%) (Table 1).

Figure 2 illustrates the spatial distribution of triatomine collected in the study area.
TABLE 1: Triatomine species collected in intra- and peridomicile areas from 2008 to 2017.

| Species              | Intradomicile | Peridomicile | Total | Relative frequency (%) |
|----------------------|---------------|--------------|-------|------------------------|
|                      | adults | nymphs | total | adults | nymphs | total |       |
| Panstrongylus lutzi  | 1375   | 14     | 1389  | 36     | 0      | 36    | 1425  | 30.36  |
| Triatoma brasiliensis| 968    | 194    | 1162  | 44     | 20     | 64    | 1226  | 26.12  |
| Triatoma pseudomaculata | 943  | 39     | 982   | 42     | 29     | 71    | 1053  | 22.43  |
| Panstrongylus megistus | 834  | 43     | 877   | 72     | 15     | 87    | 964   | 20.54  |
| Triatoma spp.        | 12     | 0      | 12    | 0      | 0      | 0     | 12    | 0.09   |
| Triatoma melanocephala | 8    | 0      | 8     | 0      | 0      | 0     | 8     | 0.25   |
| Rhodnius spp.        | 4      | 0      | 4     | 0      | 0      | 0     | 4     | 0.09   |
| Panstrongylus sp.    | 0      | 0      | 0     | 1      | 0      | 1     | 1     | 0.02   |
| Triatoma infestans   | 0      | 0      | 0     | 1      | 0      | 1     | 1     | 0.02   |
| Total                | 4,144  | 290    | 4,434 | 196    | 64     | 260   | 4,694 | 100    |

FIGURE 2: Distribution of triatomines collected at the study area from 2008 to 2017.

DISCUSSION

This study reports the occurrence of vectors of CD in intradomiciliary and peridomiciliary areas of an endemic region of Northeastern Brazil. The percentage of specimens collected from intradomiciliary areas is similar to a previous study conducted in the same area, where 92.4% of triatomines were collected indoors17. These invertebrates usually live in wild environments, however due to the degradation of their natural habitats, synanthropic triatomines are frequently reported18. These arthropods are attracted by light sources in intradomicile areas19 or may be passively transported by accumulated wood or unused furniture near the houses (outdoors) inhabited by them and other synanthropic animals such as marsupials and rodents9,20.

In the study area, the vigilance of these vectors occurs both actively and passively. During the study period (2008 to 2017) a gradual reduction in the number of specimens was observed,
which may be related to an improvement in the sanitary conditions of the population. Nonetheless, the risk of vector proliferation increases with a decrease in vigilance.

Both nymphs and adults were retrieved from intradomiciliary and peridomiciliary areas. The dispersion of triatomines in different environments may be related to mating or a search for food. In this study, the presence of nymphs intradomicile indicates the formation of colonies in these environments represented by the phenomenon of domiciliation, and consequently high risk for human infection.

Various species were captured during the study (i.e., \textit{P. lutzi}, \textit{T. brasiliensis}, \textit{T. pseudomaculata} and \textit{P. megistus}), with \textit{P. lutzi} being the most frequent (30.36%). This species had been already detected in other Brazilian regions, and is relevant for the persistence of CD in endemic areas. From an epidemiological perspective, \textit{P. lutzi} plays a crucial role in the dynamic of \textit{T. cruzi} infection in Northeastern Brazil, since it feeds on a wide plethora of hosts (e.g., birds, rodents, marsupials, dogs, goats, and humans), which are of the most commonly found within the study area. On the other hand, \textit{T. brasiliensis}, apparently associated with rodents has been considered one of the most important vectors of \textit{T. cruzi} in Brazil, using as a shelter the cactus specie \textit{Pilosocereus gounellei} commonly found in the Northeastern region.

Similarly, \textit{T. pseudomaculata} and \textit{P. megistus} share a similar natural habitat and hosts. Interestingly, \textit{T. pseudomaculata} has been captured in wild ecotypes of \textit{Mimosa tenuiflora} (commonly known as \textit{jurema-preta}), a native vegetation found in the study area. Although less frequently, species of genus \textit{Rhodnius} have been detected in the area of the present study.

Findings contribute to a better understanding of the dynamics of CD in the Northeastern region of Brazil. The poor quality of housing materials and homes, especially in rural areas, provides a favorable environment for the proliferation of triatomine vectors. Unfortunately, vector transmission of CD in Brazil still occurs, and the domiciliation of the vectors observed in this study is a risk factor for the occurrence of the disease. Therefore, preventive measures based on vector control should be implemented in the study area in order to reduce the incidence of CD.

ACKNOWLEDGMENTS

The authors would like to thank Maria L.R. Rodrigues (\textit{V Gerência Regional de Saúde}) for providing the data.

Conflict of Interest

The authors declare that there is no conflict of interest.

This article is based on the PhD thesis (Postgraduate Program in Tropical Animal Science) of the first author, developed at the Federal Rural University of Pernambuco, with support from a fellowship from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

REFERENCES

1. Pan American Health Organization. Chagas disease [Internet]. Washington: Pan American Health Organization; 2019 [cited 2019 May 20]. Available from: https://www.paho.org/hq/index.php?option=com_topics&view=article&id=10&Itemid=40242&lang=en
2. Galvão C. Vetores da doença de Chagas no Brasil. Curitiba: Sociedade Brasileira de Zoologia; 2014. 289p.
3. Coura JR. The main sceneries of Chagas disease transmission. The vectors, blood and oral transmissions - A comprehensive review. Mem Inst Oswaldo Cruz. 2015; 110(3):277-282.
4. Jurberg J, Rodrigues JMS, Moreira FFF, Dale C, Cordeiro IRS, Lamas Jr VD, et al. Atlas Iconográfico dos triatomíneos do Brasil - vetores da doença de Chagas. Rio de Janeiro: Instituto Oswaldo Cruz; 2014. 58p.
5. Parente CC, Bezerra FSM, Parente PI, Dias-Neto RV, Xavier SCC, Ramos Jr AN, et al. Community-Based Entomological Surveillance Reveals Urban Foci of Chagas Disease Vectors in Sobral, State of Ceará, Northeastern Brazil. PLoS One. 2017;1-11.
6. Dias JVL, Queiroz DRM, Martins HR, Gorla DE, Pires HHR, Diotaiuti L. Spatial distribution of triatomines in domiciles of an urban area of the Brazilian Southeast Region. Mem Inst Oswaldo Cruz. 2016;111(1):43-50.
7. Fidalgo ASOBV, Costa AC, Silva Filho J D, Cândido DS, Freitas EC, Pereira LS, et al. Insect vectors of Chagas disease (\textit{Trypanosoma cruzi}) in Northeastern Brazil. Rev Soc Bras Med Trop. 2018;51(2):174-82.
8. Sarquis O, Carvalho-Costa FA, Toma HK, Georg I, Burgoa MR, Lima MM. Eco-epidemiology of Chagas disease in northeastern Brazil: \textit{Triatoma brasiliensis}, \textit{T. pseudomaculata} and \textit{Rhodnius nasutus} in the sylvatic, peridomestic and domestic environments. Parasitol Res. 2012; 110(4):1481-5.
9. Silva MBA, Menezes KR, Farias MCG, Andrade MS, Victor CCA, Lorosa ES, et al. Description of the feeding preferences of triatomine in the Chagas disease surveillance study for the State of Pernambuco, Brazil (Hemiptera: Reduviidae). Rev Soc Bras Med Trop. 2017;50(4):543-6.
10. Ribeiro AR, Oliveira RC, Ceretti Junior W, Lima L, Almeida LA, Nascimento JD, et al. \textit{Trypanosoma cruzi} isolated from a triatomine found in one of the biggest metropolitan areas of Latin America. Rev Soc Bras Med Trop. 2016;49(2):183-9.
11. Ribeiro AR, Mendonça VJ, Alves RT, Martinez I, Araújo RF, Mello F, et al. \textit{Trypanosoma cruzi} strains from triatomine collected in Bahia and Rio Grande do Sul, Brazil. Rev Saude Publica. 2014;48(2):295-302.
12. Melo CM, Cruz ACFG, Lima AFVA, Silva LR, Madi RR, Jeraldo VL, et al. Triatoma fauna and recent epidemiological dynamics of Chagas disease in an endemic area of Northeast Brazil. Can J Infect Dis Med Microbiol. 2018;2018:1-13.
13. Carbajal De La Fuente AL, Dias-Lima A, Lopes CM, Emperaire L, Walter A, Ferreira A, et al. Behavioral plasticity of triatomines related to habitat selection in Northeast Brazil. J Med Entomol. 2008;45(1):14-9.
14. Ministério da Saúde (MS). Sistema de Informação de Atenção Básica – SIAB. Cadastramento familiar, Pernambuco. DATASUS [Internet]. Brasília: Ministério da Saúde; 2015 [cited 2019 Jan 10]. Available from: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?siab/cnv/SIABFPE.def.
15. Ayres M, Ayres M Jr, Ayres DL, Santos AA. BIOESTAT – statistical applications on the biomedical sciences. Ong. Mamirauá. 2007.

16. Ramos APM, Marcato Junior J, Decanini MMS, Pugliesi EA, Oliveira RF, Paranhos Filho C. Avaliação qualitativa e quantitativa de métodos de classificação de dados para o mapeamento coroplético. Rev Bras Cartogr. 2016;68(3):609-29.

17. Silva MBA, Barrero AVMS, Silva HA, Galvão C, Rocha D, Jurberg J, et al. Synanthropic triatomines (Hemiptera, Reduviidae) in the state of Pernambuco, Brazil: geographical distribution and natural Trypanosoma infection rates between 2006 and 2007. Rev Soc Bras Med Trop. 2012;45(1):60-5.

18. Cominetti MC, Csordas BG, Cunha RC, Andreotti R. Geographical distribution of Trypanosoma cruzi in triatomine vectors in the State of Mato Grosso do Sul, Brazil. Rev Soc Bras Med Trop. 2014;47(6):747-55.

19. Carbajal De La Fuente AL, Minoli SA, Lopes CM, Noireau F, Lazzari CR, Lorenzo M. Flight dispersal of the Chagas disease vectors Triatoma brasiliensis and Triatoma pseudomaculata in northeastern Brazil. Acta Trop. 2007;101(2):115-9.

20. Freitas SPC, Freitas ALC, Prazeres SM, Gonçalves TCM. Influência de hábitos antrópicos na dispersão de Triatoma pseudomaculata Corrêa & Espinola, 1964, através de Mimosa tenuiflora (Willdenow) (Mimosaceae) no Estado do Ceará, Brasil. Cad Saúde Pública. 2004;20(1):333-6.

21. Caranha L, Lorosa ES, Rocha DS, Jurberg J, Galvão G. Estudo das fontes alimentares de Panstrongylus lutzi (Neiva & Pinto, 1923) (Hemiptera: Reduviidae: Triatominae) no Estado do Ceará. Rev Soc Bras Med Trop. 2006;39(4):347-51.

22. Valença-Barbosa C, Lima MM, Sarquis O, Bezerra CM, Abad-Franch F. Short Report: A common Caatinga cactus, Pilosocereus gounellei, is an important ecotope of wild Triatoma brasiliensis populations in the Jaguaribe Valley of Northeastern Brazil. Am J Trop Med Hyg. 2014;90(6):1059-62.