

# Home invasion of triatomines increases the risk of Chagas disease transmission in the Brazilian Amazon

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## Research

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# Abstract

Chagas disease is a parasitic infection with a large reemergent rates in some Amazon regions with usual features of outbreaks of the acute disease mainly by oral transmission. The main vectors of *Trypanosoma cruzi* are hematophagous insects, the triatomines. Some of them can establish themselves in human dwellings and their annexes but others are mostly wild. In the state of Pará, few records have been made about the occurrence of those wild vectors in fortuitous contact with inhabitants in riverside regions in the Amazon. These vector behaviours have been studied by our group since 2006, trying to explain their role in transmission of the silent disease or asymptomatic infection. The objective of this study is to describe the epidemiological profile of populations exposed to random triatomine home invasion in riverside areas with this registered occurrence. This is a cross-sectional study developed in Abaetetuba city, in the state of Pará, where we conducted a seroepidemiologic survey in inhabitants that registered triatomine home invasion. The results demonstrated that triatomine invasions occur especially in the in-home environment and in the rural zone. The genus *Rhodnius* was the most found in residences of the municipalities. Direct contact through the vector was reported by 15.55% of the total participants, and an unusual vector behaviour were observed during the day. Despite this small casuistic, 0.47% of the enrolled inhabitants had positive serology IgG anti- *T. cruzi* antibodies. We confirm one occurrence of asymptomatic infection in a child and, also, favourable links to the Chagas disease transmission chain. Faced with the scarcity of information on triatomine aggression in the Amazon, the authors recommended an entomological study of greater scope in those areas. The record of unusual vector behaviour and the serological surveillance of human populations under this risk may constitute a new tool for the early detection of silent infections and reinforce the knowledges about the behaviour of invading insects. At the same time, health education can assist in strategies for the prevention of Chagas' disease.

## Background

Chagas disease (CD), an anthroponosis, is a parasitic infection resulting from several anthropic activities and economic and social factors [1]. *Trypanosoma cruzi* transmission occurs in several ways, such as through contact with the feces of infected blood-sucking triatomines, blood transfusion, vertical transmission, and even indirectly through the ingestion of foods and drinks contaminated with feces from the infected triatomines. The most cited form of notification systems in the Brazilian Amazon corresponding to the acute phase of the disease [2, 3].

The vectors of *T. cruzi* are hematophagous insects, hemiptera, belonging to the Reduviidae family and subfamily Triatominae that can be transmitted through direct contact with at-risk human with his/her contaminated excreta [4, 5].

Some species of triatomines are able to settle in human dwellings and their annexes, colonizing the domicile or peridomicile, generating proximity, and, therefore, potentially transmitting CD. Other species

have never been described as capable of colonizing the human households, but they can be transmitted [6, 7].

The disease is classified into two clinical phases: acute and chronic. Considering the descriptions of classical areas of vector transmission, the acute phase is characterized by manifestations of febrile disease or oligosymptomatic conditions, and in the chronic phase, several forms are described: the undetermined, asymptomatic form, the cardiac form, the digestive form, and the mixed forms [4, 8–10].

However, the descriptions of the Brazilian Amazon present a difference in the descriptions of these two phases, with a higher incidence of acute phase registries with significant clinical manifestations of a prolonged febrile syndrome due to the higher frequency of cases occurring through the highly effective transmission route, that is, the oral route. The region has never been free of *T. cruzi*, which is involved in a well-established enzootic cycle among wild animals in the region [11]. Since vector transmission has been overlooked in the region, with the assessment centered on febrile patients, the frequency of CD in its silent or asymptomatic form or as it is called in its classical description, the undetermined form, is underestimated [12]. In the Amazon, there are few, but important, reports of triatomines invading the houses of residents living the river regions [13].

In addition to the complex social and food factors of CD transmission in Amazonian outbreaks, wild-type *T. cruzi* vectors appear to be rapidly adapting to new climatic conditions and the approach to urban and periurban environments has been increasingly here and in another Latin American countries [14, 15].

Occasional contacts of triatomines to humans in the riverside regions of the Amazon have been initially studied in their role in the transmission of silent disease. In few cross-sectional studies directed to vectors, some associations between this type of contact and the incidence of infection in the State of Amazonas have been demonstrated [16]. In Pará, the state with the highest incidence of CD, few records have been established in the regions of wild vector occurrence [17], besides any records without association with the evident disease, contrary to what is observed in oral transmission [12].

Therefore, about this new epidemiological scenario of the Amazon region, it is necessary to describe the unusual behaviors of triatomines invading homes of the residents in the Pará riverside areas. Simultaneously, populations exposed to vectors, should be monitored for preventive purposes and for design health education strategies to prevent the potential *T. cruzi* infections by any transmission routes.

## Methods

Two studies were conducted by cross-sectional studies. One of them using data collected by the local service Abaetetuba Municipality Health Secretariat (AMHS) during 2014y (study I) and another prospectively (study II) in 2017, both executed in in the Municipality of Abaetetuba, Pará state, where populations exposed to contact with vectors have been reported, since 2006 according to the studies made by our group [12]. Prospectively, in 2017, records of home invasions were again observed and

corroborated by the local epidemiological surveillance sector of the AMHS, that maintains the same systematic records made in 2014.

## Ethical Aspects

All participants provided informed consent for inclusion in the study. For the retrospective study, the term was waived since data collection was characterized as an activity of the local surveillance sector.

## Procedures

Regarding the cross-sectional study I, epidemiological records registered by the epidemiological surveillance sector of the the Abaetetuba Municipality Health Secretariat (AMHS) regarding respondents who brought in spontaneous demands insects collected in their own homes or peridomicile were analyzed. The following variables were analyzed: family epidemiological history; individual epidemiological history; insect contact with the skin; information gathered about the invasive insects, as defined in Table 1. Insect analysis results were analyzed by AMHS technicians.

The victims themselves presented several photographic records of some of the aggressive behaviors of triatomines to the researchers.

For the cross-sectional prospective study, a seroepidemiological survey was conducted from August 2017 to May 2018 based on the record of spontaneous demand for the occurrence of home invasions. Home visits were conducted to conduct an interview with the asymptomatic volunteers, with the collection of blood samples in view to tests for anti-*T. cruzi* immunoglobulin G (IgG) antibodies. From these participants, 10 mL of brachial vein blood sample was collected. Two serological techniques, a qualitative indirect hemagglutination (IH) and indirect immunofluorescence (IIF), were performed.

For the localization of occurrences, the communities/houses/localities coordinates were collected using a Global Positioning System device to produce a map containing the location points of the triatomines invading the homes of the residents.

Table 1

– Criteria for defining the study variables for form application

VARIABLE	DEFINITIONS
Asymptomatic	Resident in the studied areas without complaints of recent febrile illness and without clinical manifestations of the disease
Contact with barber	Volunteer who reports seeing the triatomine in certain rooms of his/her home and/or in attachments in the home or peridomiciliary environment Or volunteer who reports having direct contact with the barber, such as in the act of capturing/hitting/crushing/storing the insect
Random sting by the barber	Individual reporting a triatomine bite at home or peridomiciliary environment
Relationship with cleaning, deforestation, or burning	Participant who reports performing these tasks near the place of residence
Home environment	Barbers that were discovered inside the house such as bedroom, living room, kitchen, and bathroom
Peridomiciliary environment	Barbers that were discovered in the annexes of the residence such as the patio and backyard

## Triatomine Identification

For both studies, the taxonomic identification of the insects captured and brought alive was performed by the surveillance sector of the AMHS using the same criteria described by Lent and Wygodzinsky [5]. Regarding the captured insects, both taxonomic identification and infectivity for *T. cruzi* were performed by sampling at the Central Pará Laboratory (LACEN-PA) and in the Chagas Disease Laboratory at Evandro Chagas Institute.

## Statistical Analysis

The frequencies of the variables of interest were described using the Epi Info version 7.2 program. Demographic data, invasion occurrence data, and vector behavior were analyzed as descriptive statistics. Temporal and spatial rates of asymptomatic infection in the studied population were described.

## Results

### Cross-Sectional study I

During 2014, 70 records of residents who spontaneously mentioned the detection of triatomine insects in their homes or peridomicile were evaluated in Abaetetuba (Table 2). Among these residents, eight reported being bitten by insects including reports of insects containing blood, suggesting that the insect

made repast in the person. The aggressive behavior of the insects was predominantly observed in women and young students.

The entomological surveillance recorded 22 species of triatomines. *Rhodnius pictipes* represented 72.72% of the survey and *Panstrongylus geniculatus* 27.28%. Injuries resulting from the aggressive behavior or stinging showed local inflammatory process with lesions of immediate evolution following the stinging or aggression sequence of multiform aspect, including flat rash, erythematous papule with more intense erythematous halo, and erythematous micropapules. All were localized in a single or focal form, but with evidence that one or more insect repast attempts were made at the same location with two or more closely related papules observed (Fig. 1). Local symptoms of pruritus and pain were also observed.

Table 2

– Sociodemographic characteristics of individuals with recorded occurrence of triatomine invasion in their residence, Abaetetuba, Pará, 2014

<b>Variables</b>	<b>Frequency</b>	<b>%</b>
Municipality of residence		
Abaetetuba	70	100
Location zone		
Rural	70	100
Sex (gender)		
Female	42	60.00
Male	28	40.00
Age range		
< 10	8	11.43
10–20	9	12.86
21–30	10	14.29
31–40	18	25.71
41–50	8	11.43
> 50	17	24.29
Occupation		
Healthcare agent	3	4.29
Retired	3	4.29
Independent worker	10	14.29
Merchant	4	5.71
Housewife	17	24.29
Domestic worker	7	10.00
Student	14	20.00
Farmer	5	7.14
Bricklayer	3	4.29
*Child ≤ 3 years-old		

Variables	Frequency	%
Teacher	2	2.86
Not applicable*	2	2.86
Triatominal aggression Yes	8	11.42
No	62	88.58
*Child $\leq$ 3 years-old		

Location and types of skin lesions resulting from the triatomines' aggressive behavior against the residents in the study area. Abaetetuba, 2014

## Cross-sectional Study II

It was conducted between August 2017 and May 2018 involving 75 participants with records of the presence of triatomines in their homes, 100% of them in rural areas (Fig. 2). A rate of 56.0% of the participants stated that they were able to work at the açai production chain (Table 3).

*R. pictipes* was the species most frequently found by participants and this species was predominantly observed during May, with the highest peak during July and August (Fig. 3) and predominantly at night.

Regarding the location of the house where the residents found the triatomines, all 75 participants reported intradomiciliary home, with the bedroom being the most predominant with 44.0%, followed by the room 42.67%, and other rooms 13.33%, and the triatomines were predominantly observed at night (Table 4).

Location of occurrences of home invasions of triatomine Abaetetuba

Seasonal distribution of insect encounters in spontaneous and intradomiciliary areas, according to the month of the year, Abaetetuba, 2017

Table 3

– Sociodemographic characteristics of residents and their houses invaded by triatomines

<b>Variables</b>	<b>Frequency (N = 75)</b>	<b>%</b>
Sex (gender)		
Female	42	56.0
Male	33	44.0
Age range		
< 10	18	24.0
10–20	15	20.0
21–30	20	26.7
31–40	7	9.3
41–50	7	9.3
> 50	8	10.7
Occupation		
Healthcare agent	1	1.3
Craftswoman	1	1.3
Housewife	5	6.7
Student	28	37.3
Farmer	28	37.3
Fisherman	9	12.0
Not applicable*	3	4.0
Works with acai		
No	33	44.0
Yes	42	56.0
House type		
Wood	64	85.3
Masonry	2	2.7

\*Child ≤ 3 years-old

<b>Variables</b>	<b>Frequency (N = 75)</b>	<b>%</b>
Wood/masonry	9	12.0
Roof type		
Tile	59	78.7
Clay	10	13.3
Straw	6	8.0
Cracks		
Yes	74	98.7
No	1	1.3
Own plantation		
Yes	73	97.3
No	2	2.7
Palm trees		
Yes	68	93.2
No	5	11.24
Relationship with cleaning/deforestation/burning		
Yes	39	52.0
No	36	48.0
Animal husbandry		
Yes	43	57.3
No	32	42.7
Animals in the peridomicile		
Yes	73	97.3
No	2	2.7
*Child $\leq$ 3 years-old		

Table 4  
 – Period of the day of the occurrence of  
 triatomine invasion in the  
 peri-/intradomiciliary environment.  
 Abaetetuba, 2017–2018

<b>Invasion shift</b>	<b>Frequency</b>	<b>%</b>
Night	43	57.33
Morning	17	22.67
Morning and night	11	14.67
Indefinite	4	5.33

## Records Of The Insects' Aggressive Behaviors

Among the respondents, 24 (32%) reported having been victims of insect bites, and one (1) of them (1.3%) was not able to report if he/she was bitten by the insect. Among the victims, most live in Abaetetuba, and the prevalent age range was between 21 and 30 years (41.7%); however, children aged less than 10 years also experienced stings. The most frequently injured body regions were the upper limbs and trunk, in which 91.7% of residents observed injury at the bite site (Table 5). The characteristics of the lesions varied, presenting as a painless, mildly itchy erythematous and/or papular erythematous spot.

Table 5  
 – Distribution of demographic data and characteristics of participants who reported triatomine bites. Abaetetuba, State of Para, 2017–2018

<b>Variables</b>	<b>Frequency</b>	<b>%</b>
Sex (gender)		
Female	12	50.00
Male	12	50.00
Age range		
< 10	3	12.50
10–20	5	20.83
21–30	10	41.67
31–40	2	8.33
41–50	3	12.50
> 50	1	4.17
Occupation		
Healthcare agent	1	4.17
City hall assessor	1	3.33
Housewife	1	4.17
Student	4	16.67
Farmer	14	58.33
Fisherman	2	8.33
Not applicable*	2	8.83
Body region		
Upper limbs	7	29.17
Upper body	8	33.33
Lower members	5	20.83
Upper and lower limbs	2	8.33
*Child ≤ 3 years-old		

Variables	Frequency	%
Neck	1	4.17
Trunk and lower members	1	4.17
Sting site injury		
Yes	22	91.67
No	2	8.33
Febrile symptom presented		
Yes	7	29.17
No	17	70.83
*Child $\leq$ 3 years-old		

## Serological Survey Test Results

Of the 145 sera analyzed, 99.32% tested were negative for IgG anti-T. cruzi antibodies. One (0.68%) had positive serology and was asymptomatic. This seropositive person is male, 12 years old student resident in Abaetetuba. He is asymptomatic and with cardiac examinations by electrocardiogram and echocardiogram were normals. It was considered a case of CD in the indeterminate form; hence, the participant received a specific medication.

## Discussion

Combined with the constant natural or anthropic environmental changes experienced by the region, the Brazilian Amazon has been a vulnerable region to CD since the report of existing parasitic cycles in the region, favoring the constant proliferation of favorable conditions for transmission.

Triatomines invading houses is a phenomenon already described previously by Coura et al. [18]. In the Municipality of Caxias, State of Rio de Janeiro, houses were investigated, and the presence of triatomines of the genus *Triatoma* was reported. In rural Jurema, Minas Gerais, it was observed that the species *Triatoma sordida* continues to colonize the houses [19]. In the municipalities of Araçatuba and Birigui, in the State of São Paulo, specifically in its urban area, the frequent presence of *Rhodnius neglectus* in apartment buildings has been reported, including signs of colonization [20].

The adaptation of triatomines to the human habitat, with abundant food supply, may be related to the continuous production of carbon dioxide, besides the detection of odors driven by drafts, even at long distance from the hosts, which increases the locomotor activity of these insects; hence, triatomines leave their current habitat [21, 22].

The Amazonian environment is complex and can be compared to the complexity of CD transmission itself. Our results transversely show for the first time the frequent invasion of triatomines in human dwellings, and this suggests the potential risk of *T. cruzi* transmission to the residents of the Northeastern Pará region.

Dujardin et al. [23] expressed concern that *Rhodnius* insects, the most abundant species in the Amazon region, are invading houses in Brazil, and its main ecotopes include palm trees located near human residences [24]. In our findings, the species most often found in the homes of the residents was the *R. pictipes* species. Moreover, in the Amazon, there are at least 10 species of *T. cruzi*-infected triatomines already described [25].

In other studies, the most reported non-domiciled species in the Tocantins State residences, an area bordering the Amazon, is similar with our results. Similarly, in rural and urban locations in Manaus, the triatomines collected corresponded mostly to the species *R. pictipes*, with no evidence of home colonization [26, 27].

In Abaetetuba city, in the State of Pará, the proximity of the wild vectors to the human domicile was described for the first time [13]. Moreover, in another riverside community in Muaná city, situated in Marajó Island, four species of triatomines were collected colonizing the peridomicile, including *R. pictipes* [28]. In the Municipality of Mazagão, in the State of Amapá, a search for triatomines was conducted in the village residences and three species identified as *R. pictipes* were collected. However, colonies were not found neither in the residences nor in the annexes [29].

Abad-Franch et al. [30] suggested that deforestation, associated habitat loss, and host diversity may increase the frequency of human contact with the *Rhodnius* genus. Factors that favor the invasion of this genus in new habitats are probably associated with insufficient food in natural ecotopes or strategies of dispersal and seasonality. Ecological imbalances may decrease the supply of food sources in these ecotopes [31, 32].

Most investigations of acute CD outbreaks in Amazonia report the involvement of triatomines, specifically of the genus mentioned, which emphasizes the importance of correlated studies on vector ecology and the interaction between triatomines and their ecotopes [33].

Regarding the type of housing, the study by Toledo et al. [34] in five municipalities of the northwestern Parana region included 156 *Triatoma* barbers, and the wooden-walled house was the most frequently invaded house (80%), as observed in our study, which corresponded to most homes. In our analysis, 98.67% of respondents lived in cracked houses. Perez [35] surveyed housing units related to the presence of the *T. cruzi* cycle and found that 55% of matched houses were built with uncoated brick and covered with shingles. The author suggested that the type of walls of these dwellings, with many cracks, allows the formation of shelters and consequently the formation of colonies.

Having palm trees in the annexes to the households was a significant finding. It is important to emphasize that, according to Romaña et al. [36], the presence of palm trees may be an indicator of areas at risk of CD transmission. Several *Rhodnius* species have been reported from *Attalea* complex palm species, including *Rhodnius nasutus*, *R. neglectus*, *Rhodnius prolixus*, *Rhodnius robustus*, and *R. pictipes*. In devastated burned areas, palm trees are the dominant vegetation, being considerably the only refuge for vertebrate animals [33].

Clearing and burning activities were reported by 52% of the respondents. Although 48% stated that they did not perform such activities, they are close residents to those who perform it. According to Romaña et al. [37], man-made landscape changes such as deforestation alter the population dynamics of palm trees and consequently may alter the density of *Rhodnius* populations, influencing the ecoepidemiology of CD.

The dog is a host of *T. cruzi* defined as the main domestic reservoir in several countries [38]. In the context of the home environment, raising domestic animals is part of the interviewees' daily life, just as these animals live around communities. Almeida et al. [39] found in the Municipality of São Domingos do Capim the presence of serologically positive dogs, naturally infected by *T. cruzi*, at 31%. Another similar study was conducted in Abaetetuba and Curalinho, with a prevalence of 23% and 89% of infected dogs, respectively [40].

The activities of the residents related to the extraction of the acai fruit (*Euterpe oleracea*) were questioned, considering the association already established between indirect transmission of CD by food intake and ingestion of this fruit since it may come from the field mixed with triatomines or they can be attracted to light when preparing acai juices [30]. In the present study, there are participants who acted as acai extractivist for many years, and even those who answered having another occupation, such as housewife and student, still have indirect relationship with the extractivists as they are related by blood.

Triatomines invading the homes were predominantly observed in the analysis performed through the reports provided by the Chagas Disease Control Program (PCDCh), 754 triatomines were collected in 252 reported home units in the Federal District, and in total, 46% of the triatomines were captured in the home, with *Pantarbés megistus* being the most common species captured [41]. In the Municipality of Monte Negro in Rondônia, *Rhodnius* was the predominantly found genus, representing 91% of the specimens collected inside houses [42].

In the Municipality of Diamantina in Minas Gerais, among the total insects captured, 87.9% were found inside the households [43]. The author described that the main places in the house were the bedroom (33.6%) and the living room (32.1%). These compartments were predominant in our analysis, suggesting a relationship with the attempt of insect blood repast in humans in behaviors already described in the victims' resting environments. Among the species captured, species were predominantly captured in the bedroom, which may be related to the insect search for blood sources. In another region of Pará, in the City of Barcarena, near the area under the study, the coexistence of children with barbers has been alarming. In this city, there was at least one record of an infant who acquired acute infection because he/she swallowed the insect while playing it [12].

Artificial light sources play an important factor in the invasion of triatomines at night [44], which may explain the night shift most reported by residents of the study. Most of the invasions recorded occurred at night. However, reports regarding the barbers detected in the morning shift were also noted. Such vector behavior has not yet been described in the literature, as Lorenzo and Lazzari [45] showed that during daytime, triatomines develop little locomotor activity and are commonly found in a state of immobility or akinesis (absence of voluntary movement).

An important issue to consider is the seasonality of these home invasions in July, reinforcing the study by Lehane et al. [46], in which they demonstrated the influence of flight activity of triatomines in relation to the increase of ambient temperature. The research results of Brito et al. [47] showed how different climatic factors can have distinct effects on the invasive behaviors of different triatomine species, and that excessive rainfall may make it difficult for *Rhodnius* species to fly from the Amazon, more than their close relatives of the Cerrado, *R. neglectus*. Interestingly, these temporal relationships intertwine when we also identify the seasonality of cases of acute-phase CD occurring in the same period [11].

Few published studies report on triatomine behavior. In this perspective, Matta [48] first described, in the State of Amazonas, the aggressiveness of the wild *Rhodnius brethesi* species, which stung the entire body of workers known as *piçabeiros*, causing skin inflammation [49]. In 1994 in the Municipality of Barcelos, near the Rio Negro, also in the State of Amazonas, the “attack” by vectors of this same species on human populations in *Piaçabais* was also observed. This vector behavior was associated with the fiber extraction of *Leopoldina piassaba* palm. It has been suggested that this behavior by triatomines was the first mechanism of contact with humans, preceding their adaptation to artificial ecotopes [16, 50].

Recently, Coura et al. [25] evaluated in the Rio Negro 482 patients (*piçaba* fiber collectors and their relatives) who reported knowing the *R. brethesi* species in *Piaçabais*. Additionally, 79% reported that they were stung bitten one to ten times by these insects. In the serology performed with 273 of the residents of the area, 25 were positive and claimed to have been stung more than ten times by these insects.

Regarding the profile of the residents who were victims of triatomines bites in this study, there are no other studies related to this for comparison as there is only the research of the authors mentioned above, which relate aggression with palm extraction in the Amazonas. In Pará, this behavior was initially recorded by Pinto et al. [12] in the Municipality of Abaetetuba, where all the people included in the study reported the presence of triatomines inside their homes. Nine persons (7.5%) reported being stung and one person reported experiencing seven stung in the same night, being this insect identified as *R. pictipes*. This information was justified by clinical evidence, such as the presence of erythematous spots.

Similar with the retrospective study, in the prospective study, different occupations were described, being student and farmer the most reported occupations in both time frames, and still, the occupation housewife was present in both study periods. Based on these data, we can suggest that this behavior of the triatomine is not only associated with extractive workers.

Although the prospective study confirm the occurrence of silent infections in the investigated areas despite the rare rate (one person), we observed favorable links to the CD transmission chain. It is noteworthy that in Abaetetuba in 2014, a patient who tested positive in the serological test was confirmed in a minimum sample of 75 patients who underwent the serological test. That is, a more robust case series in epidemiological survey methodologies may probably demonstrate a still underestimated quantity of asymptomatic patients who are unaware of their condition. Therefore, a strengthened epidemiological surveillance program for entomology is required, providing diagnostic access to silent transmission and concurrently avoiding reducing the risk of direct or indirect (oral) vector transmission.

In this context, through the description of residents who reported triatomine sting, 91.67% observed local injury. Our study illustrated these injuries caused by bites in the body regions, demonstrating the unusual behavior of vectors in the State of Pará, causing discomfort in the residents.

## Conclusions

These unusual behavior of triatomines in the Amazon and the environments of intense forest degradation, are not sufficient to understand the biology of the species involved and, the biological features to cause this aggressive contact between triatomines and humans are significantly relevant to we strengthen the entomological surveillance.

Invasions of triatomines in human habitat have epidemiological importance in the studied areas. The authors recommend a broader epidemiological and entomological study in these areas. Therefore, understanding this new scenario can generate new or reinforce old control strategies established to populations who are victims of this behavior. Perhaps with scientific evidence and a population well-informed, we decrease the risk of the disease transmission, thus contributing to the reinforcement of old strategies and the creation of new, directed to the epidemiological scenarios of Chaga diseases in the Brazilian Amazon.

## Declarations

### Competing Interests

Not applicable

### Funding

Not applicable

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