Surveillance of Chagas disease vectors in municipalities of the state of Ceará, Brazil

Teresa Cristina Monte Gonçalves[1]/+, Assilon Lindoval Carneiro Freitas[2], Simone Patrícia Carneiro Freitas[1]

[1]Setor de Entomologia Médica e Forense, Laboratório de Transmissores de Leishmanioses, Instituto Oswaldo Cruz-Fiocruz, Av. Brasil 4365, 21045-900 Rio de Janeiro, RJ, Brasil [2]20ª Célula Regional da Saúde, Crato, CE, Brasil

The present study aimed to analyse the dwelling infestation rates and the distribution and natural Trypanosoma cruzi *infection rates, among triatomines captured in the 13 municipalities of the state of Ceará. The records relating to the capture of intradomicile and peridomicile triatomines during the Chagas disease control program of 1998-2008 were available. Among the triatomines captured and in all of the municipalities studied,* Triatoma brasiliensis *presented the highest incidence in intradomicile and* Triatoma pseudomaculata *in peridomicile and some were positive for infection by* T. cruzi. *We emphasise that it is important to have sustainable epidemiological surveillance in the region, since when the control measures decreased, the incidence of* T. pseudomaculata *in intradomicile grew.*

Key words: Triatominae - distributions - natural infection - Ceará

Northeastern Brazil is a macroregion in which Chagas disease occurs endemically. A variety of vector species for the parasite *Trypanosoma cruzi* that are of public health importance are found in this region: *Triatoma brasiliensis* Neiva 1911, *Triatoma pseudomaculata* Corrêa & Espínola 1964, *Panstrongylus lutzi* (Neiva & Pinto 1923) and *Panstrongylus megistus* Burmeister 1835 (Dias et al. 2000, MS 2005).

The species *T. brasiliensis*, *T. pseudomaculata* and *P. lutzi* are native to the area and have a wide distribution across the semi-arid zones of the Northeastern region. In control program surveys, the first two species were considered to be potential vectors because they form colonies in homes, leading to a continual risk of vector transmission (MS 2005). Regarding their feeding habits, *T. brasiliensis* is moderately anthropophilic and *T. pseudomaculata* is ornithophilic (Forattini et al. 1981, Silveira et al. 1984, Freitas et al. 2005).

In 1975, the vector control actions for Chagas disease in Brazil became systematised and the programs attained nationwide scope (Silveira et al. 1984). In 2000, the epidemiological surveillance was maintained in the areas covered by decentralisation of health services, when municipalities then started to carry out the actions within the program (Diário Oficial da União 2004).

The present paper analyses the dwelling infestation rates and the distribution and natural *T. cruzi* infection rates among triatomine species that occur in the municipalities that make up the 20ª Célula Regional da Saúde (CERES) of the state of Ceará (CE). These results will provide information regarding the present situation of the Chagas disease control programs in these municipalities.

+ Corresponding author: tcmonte@ioc.fiocruz.br
Received 15 June 2009
Accepted 19 October 2009

MATERIALS AND METHODS

CE covers an area of 148,016 km^2 and has a coastline extending for 538 km. Most of this area consists of topographically low-lying, semi-arid terrain (Alencar et al. 1976).

In the present paper, records relating to triatomine capture during the Chagas disease control program of 1998-2008 were analysed. These records were from 13 municipalities: Altaneira, Antonina do Norte, Araripe, Assaré, Campos Sales, Crato, Farias Brito, Nova Olinda, Potengi, Salitre, Santana do Cariri, Tarrafas and Várzea Alegre. This region covers an area of 8.686 km^2 and is located in the Cariri region of the southern CE, at the boundaries of the states of Piauí and Pernambuco (between latitudes 6º41'40"N and 7º39'00"S and longitudes 39º37'20"E and 40º30'00"W). The Cariri region has a hot climate for most of the year and its vegetation is predominantly *caatinga*.

Specimens were captured intradomicile and peridomicile, in rural localities, according to Manual de Normas Técnicas da Superintendência de Campanhas de Saúde Pública (MS 1980). In addition, the prevalence of the distribution of the vector species and the occurrence of natural infection by *T. cruzi* in triatomines were analysed as indicators for the relationship between triatomines and *T. cruzi* and as operational indicators.

According to standard Pan American Health Organization procedures (PAHO 2007), the following rates were calculated: the infestation rates of each of the municipalities (number of positive homes x 100/total number of examined homes), the infestation peridomicile rates (number of homes with vectors in peridomicile x 100/number of examined homes with peridomicile), the infestation intradomicile rates (number of homes with vectors in intradomicile x 100/number of examined homes with intradomicile), the dispersion rates (number of locality infested x 100/total number of locality examined) and the natural infection rates by *T. cruzi*, represented by the number of infected vectors x 100/number of examined vectors.

RESULTS

In the 13 municipalities studied, between 1998-2008, a total of 36,204 triatomine specimens were captured, 10,740 adults and 25,464 nymphs. Among these, the highest number species captured was *T. pseudomaculata*, with a prevalence of nymphs in peridomicile. This was followed by *T. brasiliensis*, which also presented with a higher number of nymphs in peridomicile. *Rhodnius nasutus* Stål, 1859, followed, also with the highest number of nymphs in peridomicile and with a low prevalence in intradomicile. In addition, other captured species were *P. lutzi* which had the greatest number of insects captured as adults in intradomicile and *P. megistus*, which similarly had the highest number of nymphs in peridomicile (Table I).

In 2001, the greatest number of specimens was captured, with a total of 6,623 (18.29%) specimens. This was followed by 2005 with 5,542 (15.3%), 2004 with 3,480 (9.61%), 2002 with 3,358 (9.27%), 2006 with 3,241 (8.95%), 1999 with 2,987 (8.25%), 2007 with 2,881 (7.96%), 1998 with 2,834 (7.82%), 2003 with 2,737 (7.6%); 2008 with 1,748 (4.82%), and 2000 with 773 (2.13%) (Fig. 1).

The *T. brasiliensis* species had the high prevalence in intradomicile in all of the years and municipalities, followed by *T. pseudomaculata*, *P. lutzi*, *R. nasutus* and *P. megistus* (Fig. 2, Table II). The lower rates of triatomines in the intradomicile and peridomicile were observed in the municipalities of Altaneira, Crato and Nova Olinda. On the other hand, higher rates occurred in Potengi, Assaré and Várzea Alegre (Table III). The city of Várzea Alegre had not only the highest number of homes with insects, but also had the highest dispersion rates (Table III).

Várzea Alegre had the highest number of triatomines infected with *T. cruzi* with 64 insects infected; 10 of the insects were *T. brasiliensis* (4 adults and 3 nymphs), 53 were *T. pseudomaculata* (23 adults and 30 nymphs) and one adult was *P. megistus*. The municipalities of the Altaneira and Antonina do Norte had the lowest number of infected insects, with only one adult and two nymphs of *T. pseudomaculata* and one adult and one nymph of *T. brasiliensis*. However, the highest natural infection rates were recorded in the city of Araripe, while the lowest rates were recorded in Antonina do Norte. With regard to species, *T. pseudomaculata* had the highest number of positive specimens, although *P. megistus* and *P. lutzi* had the highest natural infection rates (Supplementary data).

DISCUSSION

The operational procedures of the Fundação Nacional de Saúde have been detailed and their impact on endemic disease monitoring and vector control in nine states of Northeastern Brazil has been analysed. Previous studies have put an emphasis on the process of domestication of triatomines in different regions of Northeastern Brazil, thus providing a warning about future public health problems (Alencar et al. 1976, Dias et al. 2000, Costa et al. 2003, Sarquis et al. 2004, 2006).

All of the species were captured both intradomicile and peridomicile. The latter environment had a greater prevalence of vectors, which may indicate the possibility of acceleration in the process of intradomicile re-infestation. The process of intradomicile re-infestation is influenced by the existence of animals in peridomicile and the shelter conditions that the vector finds in the human habitation (Silveira et al. 2001, Freitas et al. 2004b).

The highest number of captured insects in all of the municipalities was *T. pseudomaculata*. However, currently, *T. brasiliensis* still exhibits the highest number of captured specimens in intradomicile in the Cariri region and has not yet been replaced by *T. pseudomaculata*. Although, it has been suggested that a process of replacement of *T. brasiliensis* by *T. pseudomaculata* may be occurring (Silveira et al. 2001). In addition to this region, *T. pseudomaculata* has also been found in wild environments (Freitas et al. 2004b).

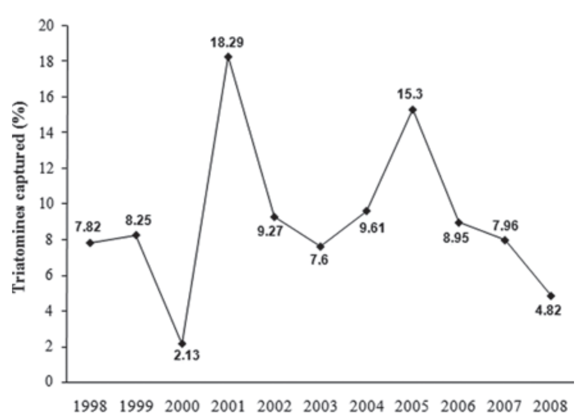

Fig. 1: annual percentage of triatomines captured in intradomicile and peridomicile of 13 municipalities of 20ª Célula Regional da Saúde, period 1998-2008. Percentage calculation: total number triatomines captured for year x 100/total general triatomines captured.

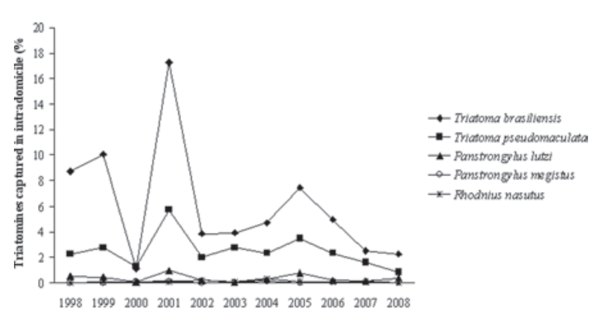

Fig. 2: annual percentage of triatomines captured in intradomicile of 13 municipalities of 20ª Célula Regional da Saúde, period 1998-2008. Percentage calculation: total number triatomines captured in intradomicile/year x 100/total general triatomines captured in intradomicile.

TABLE I

Total specimens captured in domicile (intra) and peridomicile (peri) in the 13 municipalities in Ceará, period 1998-2008

	Rhodnius nasutus					*Triatoma pseudomaculata*					*Panstrongylus lutzi*					*Panstrongylus megistus*					*Rhodnius nasutus*					Total			
	Intra		Peri		T	Intra		Peri		T	Intra		Peri		T	Intra		Peri		T	Intra		Peri		T	Intra		Peri	
Municipalities	A	N	A	N		A	N	A	N		A	N	A	N		A	N	A	N		A	N	A	N		A	N	A	N
Altaneira	7	3	9	17	36	2	1	80	246	329	4	0	1	0	5	0	0	0	0	0	0	3	2	1	6	13	7	92	264
Antonina do Norte	105	171	64	216	556	4	22	50	174	250	4	1	1	0	6	1	0	1	0	2	0	0	0	0	0	114	194	116	390
Araripe	38	24	21	147	230	32	92	701	3,118	3,943	18	0	0	1	19	0	0	0	1	1	0	0	0	0	0	88	116	722	3,267
Assaré	158	221	116	492	1,037	20	51	612	1,238	1,921	3	0	1	0	4	0	0	1	0	1	0	0	9	3	12	181	272	789	1,733
Campos Sales	236	260	167	412	1,075	16	33	510	1,394	1,953	68	0	5	0	73	0	0	0	0	0	0	0	0	0	0	320	293	682	1,806
Crato	38	45	29	99	211	38	106	525	1,601	2,270	11	0	26	18	55	1	1	8	26	36	10	18	267	302	597	98	170	855	2,046
Farias Brito	169	310	321	570	1,370	47	112	1,059	2,524	3,742	20	1	1	0	22	7	1	8	18	34	6	3	19	12	40	249	427	1,408	3,124
Nova Olinda	13	24	30	84	151	11	18	232	455	716	1	0	3	0	4	0	0	0	0	0	0	0	7	3	10	25	42	272	542
Potengi	137	69	93	209	508	37	57	460	1,271	1,825	7	0	6	0	13	0	0	0	0	0	1	0	0	0	1	182	126	559	1,480
Salitre	11	6	25	72	114	7	5	461	820	1,293	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	20	11	486	892
Santana do Cariri	22	49	16	125	212	15	79	360	1,173	1,627	4	0	1	3	8	3	1	4	11	19	1	2	45	28	76	45	131	426	1,340
Tarrafas	57	127	191	663	1,038	12	23	410	1,233	1,678	1	0	1	3	5	0	0	0	1	1	0	0	8	13	21	70	150	610	1,913
Várzea Alegre	199	321	422	811	1,753	106	212	1,550	3,344	5,212	17	5	7	10	39	3	5	1	8	17	3	0	10	12	25	328	543	1,990	4,185
Total	1,190	1,630	1,554	3,917	8,291	347	811	7,010	18,591	26,759	160	7	53	35	255	15	8	23	65	111	21	26	367	374	788	1,733	2,482	9,007	22,982
%	3.29	4.5	4.3	10.9	22.9	0.95	2.24	19.4	51.53	73.9	0.44	0.01	0.14	0.03	0.7	0.04	0.02	0.06	0.17	0.3	0.05	0.07	1.01	1.03	2.2	4.78	6.85	24.87	63.5

percentage of the each municipality: total number triatomines captured for municipalities x 100/total general triatomines captured (source: 20ª Célula Regional da Saúde). A: adults; N: nymphs; T: total.

TABLE II

Total specimens captured in the domicile (intra) in the 13 municipalities in Ceará, 1998-2008

	1998				1999				2000				2001				2002			
	Intra				Intra				Intra				Intra				Intra			
Species	A	N	T	%	A	N	T	%	A	N	T	%	A	N	T	%	A	N	T	%
Triatoma brasiliensis	161	207	368	8.73	175	250	425	10.08	9	37	46	1.09	368	361	729	17.29	47	116	163	3.86
Triatoma pseudomaculata	30	66	96	2.28	32	85	117	2.77	7	46	53	1.3	77	166	243	5.77	31	52	83	1.97
Panstrongylus lutzi	19	2	21	0.5	20	0	20	0.47	2	0	2	0.04	42	0	42	1.0	4	4	8	0.19
Panstrongylus megistus	0	1	1	0.02	0	1	1	0.02	2	1	3	0.07	3	4	7	0.16	0	0	0	q0
Rhodnius nasutus	1	0	1	0.02	2	0	2	0.04	0	0	0	0	2	2	4	0.09	5	3	8	0.19
Total	211	267	287	11.55	229	336	565	13.4	20	84	104	2.5	492	533	1,025	24.31	87	175	262	6.21

percentage of triatomines in intradomicile/year: total number triatomines captured in intradomicile each year x 100/total general triatomines captured in intradomicile (source: 20ª Célula Regional da Saúde). A: adults; N: nymphs; T: total.

The low number of vectors captured in the municipalities of Altaneira, Antonina do Norte, Nova Olinda and Salitre could be due to several factors. In Altaneira, the captures were constantly interrupted and were sometimes not performed; this is apparent in data from the research activity of 20ª CERES, where the municipality activities started on 2001. Moreover, the territorial extension of the municipality is the smallest of the other 12 covered by CERES, which also could lead to a number lower. In Antonina do Norte and Salitre (personal communication), the infestation might be higher; however, the lack of systematisation of services has compromised the number of notifications. It is important to emphasise that Antonina do Norte borders the municipalities of Campos Sales, Tarrafas and Assaré, and Assaré is the municipality that has both high rates of infestation and dispersion.

It is important to draw attention to the surveillance services in Assaré, Potengi and Várzea Alegre, since infestation rates and dispersion of triatomines in these municipalities show the highest rates. This may be due to the presence of factors such as environmental conditions, vegetation, food, territorial proximity and the use of wood for building animal shelters (Freitas et al. 2004b); all of which can influence the dispersion of triatomines to areas that are typically not covered in the surveillance, contributing to the maintenance of triatomines in region.

The low natural infection rates by *T. cruzi* in the Cariri region may be due to the fact that most species have been collected in peridomiciliary annexes, where the predominant food source is the blood of birds (Freitas et al. 2005). Moreover, the CERES, responsible for laboratory analysis of insects sent by several municipalities, continually have difficulty in analysing the volume of material, leaving the vectors in a period of fasting. This starvation sometimes causes death and according to the protocol used by the CERES, these insects are then not analysed. It is important to emphasise that although low, the rates of infection in *T. brasiliensis* and *T. pseudomaculata* are important, since these insects are found primarily in intradomicile and peridomicile, at all stages of development, and have a food source that is the blood of domestic animals and humans, which keeps the Chagas disease cycle present in these environments.

The same attention needs to be given to *R. nasutus*, which is a species predominantly found in wild habitats. *R. nasutus* has often been found to colonise artificial ecotopes in peridomicile and are sometimes infected with *T. cruzi* (Silveira & Vinhaes 1998, Sarquis et al. 2004) or have a mixed infection with *Trypanosoma rangeli* (Dias et al. 2008). The authors of the last paper suggest the need for epidemiological surveillance in the region of the Chapada do Araripe, since that palm trees close to home are infested with *R. nasutus* that are infected by *T. cruzi*, demonstrating the importance of maintenance of sylvatic *T. cruzi* transmission in this area.

According to PAHO (2007), the rate of colonisation is related to the number of domiciles, with nymphs x 100/number of homes inspected. In this study, the rate of colonisation established by PAHO (2007) could not be evaluated because the work performed by the CERES did not consider the exact number of nymphs per domicile examined. Thus, it is suggested the colonisation of wild species has occurred, since *R. nasutus*, due to the presence of nymphs in the homes, has been found annually in the region.

It is now considered that there is a risk of Chagas disease transmission due to the presence of emerging species such as *P. lutzi* (Freitas et al. 2004a). Therefore, there is a risk that the invasion by this vector may continue or persist, since the characteristics of the peridomicile (such as presence of the vector in wild environments and the presence of food) may influence the process of invasion and colonisation of the home (Freitas et al. 2004a, MS 2005). In this region, adults of this species were found to have greater capture rates in intradomicile, facilitating colonisation in this environment. Since environmental conditions were not considered in the CERES data, we

2003				2004				2005				2006				2007				2008			
Intra				Intra				Intra				Intra				Intra				Intra			
A	N	T	%	A	N	T	%	A	N	T	%	A	N	T	%	A	N	T	%	A	N	T	%
51	115	166	3.95	98	100	198	4.7	152	163	315	7.47	72	137	209	4.96	18	89	107	2.54	39	55	94	2.23
24	92	116	2.76	41	58	99	2.35	60	88	148	3.51	31	68	99	2.35	7	61	68	1.62	7	29	36	0.85
0	0	0	0	10	0	10	0.23	31	1	32	0.76	9	0	9	0.22	7	0	7	0.16	16	0	16	0.38
0	0	0	0	5	0	5	0.12	0	0	0	0	2	0	2	0.04	3	1	4	0.09	0	0	0	0
2	2	4	0.09	3	11	14	0.33	4	0	4	0.09	1	3	4	0.09	1	5	6	0.14	0	0	0	0
77	209	286	6.8	157	169	326	7.73	247	252	499	11.83	115	208	323	7.66	36	156	192	4.55	62	84	146	3.46

TABLE III

Collections in domiciles (intra) and peridominiles (peri) at 13 municipalities in Ceará, 1998-2008

	Locality					Number of domiciles					
	examinated			dispersion		infested			IR		
Municipalities	neg	pos	total	rate	examinated	intra	peri	total	intra	peri	total
Altaneira	62	68	130	52.31	6321	22	168	190	0.34	2.65	2.99
Antonina do Norte	41	161	202	79.7	6943	276	326	602	3.97	4.69	8.66
Araripe	474	435	909	47.85	29,207	157	1,576	1,733	0.53	5.39	5.92
Assaré	145	441	556	79.31	15,194	426	1,415	1,841	2.80	9.31	12.11
Campos Sales	505	565	1,070	52.8	27,599	517	1,166	1,683	1.87	4.22	6.09
Crato	439	570	1,009	56.49	48,091	206	1,282	1,483	0.42	2.66	3.08
Farias Brito	372	545	917	59.43	39,417	472	1,882	2,354	1.19	4.77	5.96
Nova Olinda	98	131	229	57.2	9,406	42	303	346	0.44	3.22	3.66
Potengi	84	230	314	73.2	8,986	211	961	1,172	2.43	10.69	13.03
Salitre	152	210	362	58.01	12,328	48	830	878	0.38	673	7.11
Santana do Cariri	278	330	608	54.27	17,349	142	763	905	0.81	4.39	5.20
Tarrafas	214	376	590	63.72	21,116	238	1,248	1,486	1.12	5.91	7.03
Várzea Alegre	209	659	868	75.92	28,080	472	2,328	2,800	1.68	8.29	9.97

dispersion rates: number of locality infested x 100/total number of locality examined; infestation intradomicile rates: number of homes with bugs in intradomicile x 100/number of homes with intradomicile examined; infestation peridomicile rates: number of homes with bugs in peridomicile x 100/number of homes with peridomicile examined; IR: infestation rates of each municipality - number of homes positive x 100/total number of homes examined; locality: term indicated to an area where there are houses, known as "site" (source: 20ª Célula Regional da Saúde).

suggest that *P. lutzi* and *R. nasutus* have remained in intradomicile because of the rainy season, which undermines the work of spraying.

Over the 11 years of the Chagas disease Control Program in 20ª CERES, there was a considerable increase in the results in 2001 and 2005. This was caused by an increase in the number of endemic disease control agents, who formed specific teams for Chagas disease and dengue control (personal communication). However, the sudden decrease that follows after these two years (2001 and 2005) represent a break from work and consequently, a decrease in the number of insects that were captured.

These results empathise previous studies in different areas (Costa et al. 2003, Sarquis et al. 2006, Freitas et al. 2007), showing the importance of the epidemiological surveillance in the Cariri region of CE. The work indicates that surveillance must be sustainable, considering that *T. pseudomaculata* and *T. brasiliensis* are native, present in the human environment of all of the municipalities and infected by *T. cruzi*.

ACKNOWLEDGEMENTS

To the Health Departments of the 13 municipalities that make up 20ª Célula Regional da Saúde, CE, for their support and the data supplied, and to the endemic disease agents, for capturing triatomines in the field.

REFERENCES

Alencar JE, Santos AR, Bezerra OF, Saraiva TM 1976. Distribuição geográfica dos principais vetores de endemias no estado do Ceará. I. Triatomíneos. *Rev Soc Bras Med Trop 10*: 261-284.

Costa J, Almeida CE, Dotson EM, Lins A, Vinhaes M, Silveira AC, Beard CB 2003. The epidemiologic importance of *Triatoma brasiliensis* as a Chagas disease vector in Brazil: a revision of domiciliary captures during 1993-1999. *Mem Inst Oswaldo Cruz 98*: 443-449.

Diário Oficial da União 2004. Portaria 1.172 (17 de junho). Revoga as Portarias 1.1399 e 1.147, Brasília, p. 58-59.

Dias FBS, Bezerra CM, Machado EMM, Casanova C, Diotaiuti L 2008. Ecological aspects of *Rhodnius nasutus* Stål, 1859 (Hemiptera: Reduviidae: Triatominae) in palms of the Chapada do Araripe in Ceará, Brazil. *Mem Inst Oswaldo Cruz 103*: 824-830.

Dias JCP, Machado EMM, Fernandes AL, Vinhaes MC 2000. Esboço geral e perspectivas da doença de Chagas no Nordeste do Brasil. *Cad Saude Publica 16*: 13-34.

Forattini OP, Barata JMS, Santos JLF, Silveira AC 1981. Hábitos alimentares, infecção natural e distribuição de triatomíneos domiciliados na Região Nordeste do Brasil. *Rev Saude Publica 15*: 113-164.

Freitas ALC, Freitas SPC, Gonçalves TCM, Lima-Neto AS 2007. Vigilância entomológica dos vetores da doença de Chagas no município de Farias Brito, estado do Ceará, Brasil. *Cad Saude Coletiva 15:* 231-240.

Freitas SPC, Freitas ALC, Gonçalves TCM 2004a. Ocorrência de *Panstrongylus lutzi* no peridomicílio, estado do Ceará, Brasil. *Rev Saude Publica 38*: 579-580.

Freitas SPC, Freitas ALC, Prazeres SM, Gonçalves TCM 2004b. Influência de hábitos antrópicos na dispersão de *Triatoma pseudomaculata* Corrêa & Espínola, 1964, através de *Mimosa tenuiflora* (Willdenow) (Mimosaceae) no estado do Ceará, Brasil. *Cad Saude Publica 20*: 333-336.

Freitas SPC, Lorosa ES, Rodrigues DCS, Freitas ALC, Gonçalves TCM 2005. Fontes alimentares de *Triatoma pseudomaculata* no estado do Ceará, Brasil. *Rev Saude Publica 39*: 27-32.

MS - Ministério da Saúde 1980. Superintendência de Campanhas de Saúde Pública. Manual de normas técnicas da Campanha de Controle da Doença de Chagas. Brasília, 166 pp.

MS - Ministério da Saúde 2005. Secretaria de Vigilância em Saúde. Consenso brasileiro em doença de Chagas. *Rev Soc Brasil Med Trop 38* (Suppl. III): 1-29.

PAHO - Pan American Health Organization 2007. Norma tecnica de prevencion y control de la enfermidad de Chagas. Ministério de Salud Pública y Asistencia Social. República de El Salvador, 58 pp.

Sarquis O, Borges-Pereira J, Mac Cord JR, Gomes TF, Cabello PH, Lima MM 2004. Epidemiology of Chagas disease in Jaguaruana, Ceará, Brasil. I. Presence of triatomines and rates of *Trypanosoma cruzi* infection in four localities of a rural area. *Mem Inst Oswaldo Cruz 99*: 263-270.

Sarquis O, Sposina R, Oliveira TG, Mac Cord JR, Cabello PH, Borges-Pereira J, Lima MM 2006. Aspects of peridomiciliary ecotopes in rural areas of Northeastern Brazil associated to triatomine (Hemiptera: Reduviidae) infestation, vectors of Chagas disease. *Mem Inst Oswaldo Cruz 101*: 143-147.

Silveira AC, Feitosa VR, Borges R 1984. Distribuição de triatomíneos domiciliados no período 1975/83. Brasil. *Rev Bras Malar Doenças Trop 36*: 15-312.

Silveira AC, Vinhaes MC 1998. Doença de Chagas: aspectos epidemiológicos e de controle. *Rev Soc Bras Med Trop 31*: 15-60.

Silveira AC, Vinhaes MC, Lira E, Araújo E 2001. *O controle de* Triatoma brasiliensis *e* Triatoma pseudomaculata, OPAS, Brasília, 86 pp.

TABLE IV

Total triatomine specimens infected by *Trypanosoma cruzi* in the 13 municipalities in Ceará, 1998-2008

	Triatoma brasiliensis								*Triatoma pseudomaculata*								*Panstrongylus lutzi*								*Panstrongylus megistus*								*Rhodnius nasutus*							
	Intra				Peri				Intra				Peri				Intra				Peri				Intra				Peri				Intra				Peri			
Municipalities	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%	C	E	I	%
Altaneira	10	8	0	0	26	19	0	0	3	1	0	0	326	314	2	0.64	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	3	2	0	0
Antonina do Norte	276	179	1	0.6	280	193	1	0.52	26	4	0	0	224	183	0	0	5	1	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Araripe	62	39	2	5.13	168	131	1	0.8	124	98	1	1.02	3,819	3,427	17	0.5	18	5	1	20	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Assaré	379	256	6	2.35	658	552	2	0.4	71	50	0	0	1,850	1,548	8	0.52	3	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	12	4	0	0
Campos Sales	496	431	10	2.32	579	491	5	1.02	49	27	1	3.7	1,904	1,610	10	0.62	68	15	1	6.66	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crato	83	71	2	2.82	128	166	0	0	144	123	3	2.44	2,126	1,962	32	1.63	11	7	1	14.28	44	34	0	0	2	2	0	0	34	33	3	9.09	28	20	0	0	569	540	10	1.85
Farias Brito	479	405	5	1.24	891	812	9	1.1	159	129	3	2.33	3,583	3,319	26	0.8	21	11	1	9.09	1	1	1	100	8	6	0	0	26	16	0	0	9	8	0	0	31	28	0	0
Nova Olinda	37	33	1	3.03	114	55	1	1.9	29	27	0	0	687	660	7	1.06	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	0	0
Potengi	206	115	1	0.9	302	247	3	1.22	94	65	9	13.85	1,731	1,559	17	1.09	7	1	0	0	6	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Salitre	17	15	0	0	97	84	1	1.2	12	12	1	8.34	1,281	1,143	3	0.26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santana do Cariri	71	65	1	1.54	141	130	1	0.8	94	82	3	3.65	1,533	1,433	17	1.19	4	2	0	0	4	4	0	0	4	3	0	0	15	7	0	0	3	1	0	0	73	69	0	0
Tarrafas	184	165	6	3.64	854	744	20	2.7	35	18	0	0	1,643	1,450	10	0.7	1	0	0	0	4	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	21	21	0	0
Várzea Alegre	520	392	3	0.8	1,233	1,076	7	0.65	318	266	5	1.88	4,894	4,398	48	1.09	22	9	0	0	17	6	0	0	8	7	1	14.28	9	9	0	0	3	2	0	0	22	22	0	0
Total	2,820	2,174	38	1.75	5,471	4,620	20	0.10	11,558	902	26	2.88	25,601	23,006	197	0.85	167	51	4	7.84	88	53	1	1.88	23	18	1	5.55	88	67	3	4.47	47	34	0	0	741	695	10	1.43

natural infection rates by *T. cruzi*: number of infected bugs x 100/number of examined bugs (source: 20ª Célula Regional da Saúde). C: captured; E: examined; I: infected; intra: intradomicile; peri: peridomicile.