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DOMESTIC VECTORS OF CHAGAS' DISEASE IN THREE RURAL COMMUNITIES OF NICARAGUA (1)

Rosário PALMA-GUZMÁN (2), Teresa RIVERA B. (3) & William MORALES G. (4)

SUMMARY

A triatomine survey was conducted in three rural settlements of Nicaragua (Santa Rosa, Quebrada Honda and Poneloya) where Chagas' disease is endemic, to determine rates of house infestation, evaluate the housing condition and to asess the performance of the María sensor box in detection of domestic vectors. A total of 184 households were selected and vectors were sought by the methods of timed manual capture and by sensor boxes. The sole vectors species found in this study was *Triatoma dimidiata*. Of the examined bugs 50, 60 and 33%, in the respective communities, were infected with *T. cruzi*. The rates of house infestation as determined by manual capture and sensor boxes were respectively, 48.3% and 54.2% in Santa Rosa, 29.8% and 51.2% in Quebrada Honda and in Poneloya 3.8 and 5.9% with significant difference between the methods in Quebrada Honda. When compared with the manual capture, the Maria sensor box detected vectors in 71.4% of positive houses in two of the communities but also was able to detect bugs in 39.3% and 41.1% of houses where manual capture had been negative. Housing condition was evaluated according to three structural parameters, in this way, in the first community 79.2% of houses were classified as bad, 20.8% as regular; in the second one 42.5% were bad and 57.5% regular, whereas in the third 62.5% of the houses were regular. Rates of infestation did not differ greatly between the different housing conditions. Our results show that the sensor box is as efficient as manual capture and could be implemented in our country.

KEYWORDS: Chagas' Disease; Triatomine vectors; Biosensor; Nicaragua.

INTRODUCTION

The existence of Chagas' disease and of its vector species in Nicaragua was first reported by URROZ et al.[12] in 1966, in a locally published journal. In 1971 a summary of the state of knowledge on Chagas' disease in Nicaragua was presented by URROZ[13] at a regional congress of microbiology. Both reports described several endemic areas in the country and identified *Rhodnius prolixus* and *Triatoma dimidiata* as the vector species, the former being by far predominant and more widely distributed. In spite of these reports, little awareness of the problem persisted among public health authorities, thus no intervention measures have still been taken. In 1995 RIVERA et al.[8] studied the prevalence of the chagasic infection in rural communities from the departments of Somoto, Masaya and León, and found seropositivities for *T. cruzi* of 13.1, 4.3 and 3.2% re-

(1) Work sponsored by SAREC (Swedish Agency for Research Collaboration with Developing countries).
(2) Titular professor. Departamento de Microbiología y Parasitología, Facultad de Medicina, UNAN-León.
(3) Vice-dean, Faculdad de Ciencias Médicas UNAN-León
(4) Titular professor. Departamento de Microbiología y Parasitología, UNAN-León.
Correspondence to: Departamento de Microbiología y Parasitología; Facultad de Medicina, Universidad Nacional Autónoma de Nicaragua. León. Apartado postal No. 68; Fax (0311) 4970.

spectively, and showed that the vectorial transmission of the disease remains active there. Many years have elapsed since the first triatomine surveys in these areas and changes in domestic vector populations as well as in housing conditions were to be expected, thus it seemed necessary to re-evaluate the entomological situation.

The most feasible mean of control of Chagas' disease is the interruption of human-vector contact through interventions such as insecticide spraying, house improvement and education. To evaluate the impact of these actions, adequate methods for measuring infestation of houses are essential. The traditional, vertically organized, man/hour/house collection method is time consuming and depends on the degree of training of the collectors. As a result, the emphasis is on alternative, cost-effective methods that are horizontally structured. In this respect the sensor boxes might be quite useful. This device has been used successfully in Brazil by GARCIA-ZAPATA[4], in Chile by SCHENONE[9] and in Argentina by WISNIVESKY-COLLI[14].

Therefore, we conducted a triatomine survey in the aforementioned areas in order to determine the rates of household infestation; to evaluate the housing conditions and to assess the applicability of the biosensor as a tool of entomological surveillance in our country.

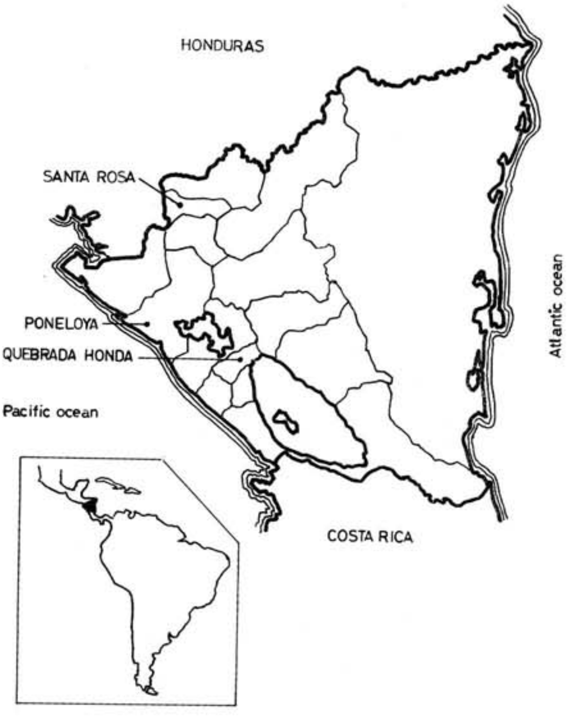

Fig. 1. Map of Nicaragua showing the localities surveyed for domestic vectors of Chagas' disease.

MATERIAL AND METHODS

Description of the study areas

Three rural communities, where Chagas' disease had been previously reported[8,13], were selected for study (Figure 1):

1) Santa Rosa, located near Somoto city, department of Madriz, in the northern zone of the country. This is a dry, subtropical area, located at 600 meters above the sea level, with a relative humidity of 50 to 60% and temperatures between 20 to 25°C. There is a wet season, from May to November and a dry season. Pluvial precipitation ranges from 1000 to 1500 mm. This is a little fertile land and the vegetation is a scrub forest. Most of the persons in the community are subsistence farmers. The main crops are corn, sorghum, and beans. The settlement has 115 houses.

2) Quebrada Honda belongs to the municipality of Masaya. It is located to the South, in the Pacific littoral at 300 meters of altitude. The climate is hot dry-tropical, also with the same dry and a wet seasons. The relative humidity is greater than 50% and average temperatures range between 24 to 30°C. Rainfall is between 1375 and 1500 mm and the vegetation is a dry tropical forest with deciduous trees. The main agricultural product are fruits. There are 120 houses in the community.

3) Poneloya, which belongs to the municipality of León, is to the Southwest, near the Pacific coast. This is also dry-tropical zone, with an altitude of 100 meters. The relative humidity and temperature ranges and rainfall are the same as in the foregoing area. The vegetation is a scrub forest. In this place the main economical activity is the cultivation of cotton. There are here 70 houses.

Triatomine survey

By systematic random, taking every other, 77, 48 and 53 houses from Santa Rosa, Quebrada Honda and Poneloya respecively, were selected for study. The types of construction materials were recorded and the presence of vectors was searched by the methods of manual capture and the María biosensor.

Manual capture: each selected house was searched by two trained persons, during half hour/man, examining with the aid of torches and forceps the walls, roofs, furniture and stored goods.

No pyrethroids for dislodging the bugs were used. The captured triatomines were carried to the Microbiology department of the Medicine Faculty of the

Universidad Nacional Autónoma de Nicaragua, León, for their classification and examination of fecal content to determine infection by *T. cruzi*.

Biosensor: The "Maria" biosensor is produced by Biotecnología Avanzada from Buenos Aires, Argentina. It is a 40 x 20 x 2 cm cardboard box inside of which there is a piece of pleated cardboard with rows of holes simulating a maze. The right and left sides are open and the top and bottom sides have slits so that the bugs can enter and leave.

Previously to its application, the house dwellers were explained about the nature and purpose of the device. Two sensors were installed on the main bedroom wall at 1 meter above the bed. The devices were then examined at 3, 6 and 9 months intervals and the presence of typical fecal deposits, or of exuvias or of alive or dead triatomines was counted as a positive finding. During each examination observed fecal deposits were marked so as not count them the next time.

Statistical comparison between the used detection methods was performed by the Chi-square test. Any relationship between house infestation and type of walls, roof and floor was sought either by the Chi-square test or the Fisher's exact text. In all cases the positivity of the biosensor is expressed as the cumulative data. The evaluation of the housing condition was performed by combining the three structural variables of roof, wall and floor according to the Bronfman's[1] model. Briefly, each category within each of the three variables was recorded as bad (B) or regular (R) or good (G) according to its potential for vector infestation and the resulting combinations were grouped in three levels of housing condition, also called bad, regular and good, by the following criterion: a bad condition was defined by any of these combinations: BBB, BBR, and BRR; a good one had: GGG or GGR and the regular condition, the rest of combinations. The Chi-square test was used for determining any relationship between housing condition and presence of triatomines.

RESULTS

The sole vector species of Chagas' disease found in the three studied communities was *Triatoma dimidiata*. Of the captured bugs 25 of 50 (50%) from Santa Rosa; 15 of 25 (60%) from Quebrada Honda and 1 of 3 from Poneloya were infected with *T. cruzi*.

The highest rates of house infestation, by both methods, were found in Santa Rosa and the lowest in Poneloya (Table 1), but there was little difference between Santa Rosa and Quebrada Honda when the biosensor rates were compared. When both detection methods were compared by the x^2 test, a significant difference was obtained for Quebrada Honda but not for Santa Rosa. No statistical results were obtained for Poneloya due to the scarcity of infested houses.

The cumulative percentages of positivity of the biosensor increased moderately with each period of examination (Table 2). In Santa Rosa 3 readings of the biosensors were performed at intervals of 30, 60 and 90 days; in Quebrada Honda only two examinations, at 30 and 60 days, could be made as thereafter most of the boxes were damaged or removed by the household dwellers and in Poneloya most biosensors were removed or destroyed by the dwellers before the first examination.

The efficacy of the biosensor to detect the bugs was compared against the manual capture. In Santa Rosa, of 28 houses determined as infected by manual capture, the biosensor, in three readings, detected vectors in 20 (71.4%) of them. However, the device could detect vectors in 11 (39.3%) of 28 houses where manual capture

TABLE 1

Infestation of households by vectors of Chagas' disease in different localities of Nicaragua, determined by two methods of detection.

	Locality					
	Santa Rosa[a]		Quebrada Honda[b]		Poneloya[c]	
Method	No. of examined houses	positive houses No. (%)	No. of examined houses	positive houses No. (%)	No. of examined houses	positive houses No. (%)
Manual search	62	30 (48.4)	47	14 (29.8)	53	2 (3.8)
Biosensor	59	32 (54.2)	43	22 (51.2)	17	1 (5.9)

Comparison of methods
a: p = 0.519
b: p = 0.038
c: not done

TABLE 2

Positivity by period of examination of the Maria biosensor in different localities of Nicaragua, 1989-1992.

	Locality					
	Somoto		Quebrada Honda		Poneloya	
Reading	No. of examined houses	positive houses No. (%)	No. of examined houses	positive houses No. (%)	No. of examined houses	positive houses No. (%)
1st (30 d.)	59	19 (32.2)	43	16 (38.1)	17	1(5.9)
2nd (60 d.)	59	25 (42.4)	43	11 (25.6)	4	1 (25.0)
3rd (90 d.)	48	22 (45.2)	ND	- -	ND	- -
Cumulated	59	32 (54.2)	43	22 (51.2)		

ND: not done

had been negative. Similarly, in Quebrada Honda of 14 houses positive by manual capture the biosensor, in two readings, detected bugs in 10 (71.4%); and revealed the insects in 12 (41.4%) of 29 houses where manual capture had failed to find them.

The determination of the construction features of the houses showed that in Santa Rosa predominate the dwellings with unplastered adobe walls, clay tile roof and dirty floor (Table 3).

In Quebrada Honda the majority of houses have walls of either wood or canes, tile or metal roof and dirty floor and in Poneloya almost all of the houses are constructed of either wood or nonplastered clay or cement bricks with roofs of tiles or metal sheet and dirty floor.

The frequencies of infestation with triatomines by type of construction material are shown in Table 4. Adobe walls were the more frequently infested in Santa Rosa but in Quebrada Honda it were the walls of cane. On the other hand, thatches had more bugs in Quebrada Honda, but in Santa Rosa only one of five examined was positive. However, no statistical association between type of construction material and presence of vectors was found.

According to the model used to determine the housing condition, in Santa Rosa 80.5% of houses were evaluated as of bad condition and 19.5% as regular. In Quebrada Honda 43.8% were bad and 56.2% regular and in Poneloya 94.3% of the households were classified as regular.

TABLE 3

Frequency of different construction materials in the households from three rural communities of Nicaragua. 1989-1991.

	Santa Rosa		Quebrada Honda		Poneloya	
Structure/Category	No. of houses	%	No. of houses	%	No. of houses	%
Roof						
Thatch	6	7.8	10	20.8	0	0.0
Tiles	67	87.0	21	43.8	32	60.4
Metal	4	5.2	17	35.4	21	39.6
Wall						
Canes/wood sticks	20	26.0	19	39.6	3	5.7
Adobe *	44	57.1	6	12.5	0	0.0
Wood	8	10.4	18	37.5	31	58.5
Brick **	5	6.5	5	10.4	19	35.8
Floor						
Soil	75	97.4	39	81.3	45	84.9
Cement	1	1.3	7	14.6	2	3.8
Tile	1	1.3	2	4.2	6	11.3

* unplastered adobe or taquezal

** clay or cement bricks, unplastered.

When categories of housing condition were related with the presence of the vector, it was found that in Santa Rosa 67.4% of bad condition houses and 58.3% of regular ones were infected by vectors (Table 5). Likewise, in Quebrada Honda, 61.1% of the bad houses and 50.0% of the regular ones were infected. But there were no significant differences in both communities. In Poneloya almost all of the houses were of regular condition and of these only 2 (4.0%) had vectors.

DISCUSSION

In 1966 URROZ et al[12]. reported the existence of both *Rhodnius prolixus* and *Triatoma dimidiata* in households from the same areas as in the present study, being the former the predominant vector species. However, we did not find *R. prolixus* in any house of the studied communities.

The disappearance of *R. prolixus* from the domiciles could be mostly due to substitution of thatches by tile or metal roofs. It has been reported[3,17] that this sole change is enough to cause a drastic reduction or to eliminate this species from the households. In fact, thatch was the less frequent type in roof in our study and there is evidence that 25 or more years ago this material was more common in these areas. It is also possible that

TABLE 4

Frequency of household infestation* with triatomines by type of construction material in three localities of Nicaragua. 1989-1991.

Structure/Category	Santa Rosa[a] Examined houses	positive houses	(%)	Quebrada Honda[b] Examined houses	positive houses	(%)	Poneloya[c] Examined houses	positive houses	(%)
Roof									
Thatch	5	1	20.0	8	6	75.0	0	0	0.0
Tiles	50	35	70.0	21	11	52.4	32	1	3.1
Metal	3	2	66.7	15	7	46.7	21	1	4.8
Wall									
Canes/wood sticks	17	10	58.8	17	11	64.7	3	0	0.0
Adobe	31	23	74.2	6	1	16.7	0	0	0.0
Wood	7	3	42.9	17	10	58.8	31	1	3.2
Brick	3	2	66.7	4	2	50.0	19	1	5.3
Floor									
Soil	57	37	64.9	35	19	54.3	45	1	2.2
Cement	1	1	100.0	7	3	42.9	2	0	0.0
Tile	0	0	0.0	2	2	100.0	6	1	16.7

* Determined by combination of the two detection methods.
p values for locality/roof, wall and floor: a) not valid; 0.397; 0.655 (Fisher). b) 0.4136; 0.227; 0.358. c) 0.64 (Fisher); not valid; 0.209.

TABLE 5

Presence* of vectors of Chagas' disease by household condition in three rural communities of Nicaragua, 1989-1991.

Condition of house	Santa Rosa[a] No. of examined houses	positive houses No. (%)	Quebrada Honda[b] No. of examined houses	positive houses No. (%)	Poneloya[c] No. of examined houses	positive houses No. (%)
Bad	46	31 (67.4)	18	11 (61.1)	3	0 (0.0)
Regular	12	7 (58.3)	26	13 (50.0)	50	2 (4.0)

* determined by combination of two detection methods.
a: p = 0.560
b: p = 0.471
c: 0.889 (Fisher exact)

the insecticide spraying by the antimalarial campaign, conducted in the past, might have indirectly contributed to the substitution of *R. prolixus* by *T. dimidiata*. A similar event was observed in Venezuela[16,17], where *T. maculata* replaced *R. prolixus* once this vector was eliminated by insecticides. Furthermore, *R. prolixus* in Central America has been described as an exclusively domiciliar species[16], thus reinfestation of houses from the peridomicile or from the forest is unlikely, in contrast with *T. dimidiata*.

Our figures of house infestation in Santa Rosa and Quebrada Honda, by manual capture (48.4 and 29.8%) are higher than those reported by URROZ[13] 25 years ago for the same areas (33 and 4.7% respectively). This is probably due to differences in methodology and to the substitution of the vector species. However, in Poneloya the rate of domiciliary infestation by manual capture (3.8%) was lower than that reported by URROZ[13] (8.4%) for the same region. This could be explained by changes in type of house and the fact that this community is amidst a cotton agricultural area that is heavily treated with pesticides.

The use of sensor boxes has been proposed as a low cost alternative for surveillance of house reinfestation in Chagas' disease control programs[14]. Moreover, it is a community-based surveillance system that can be integrated with other health programs. Both the Gómez-Núñez and the María biosensor boxes have performed as efficiently as standarized manual searching in the detection of house infestation by *Triatoma infestans*[4,9,14]. However, as the behavior of the triatomine species may differ markedly, the performance of the biosensor must be evaluated with the local vector species. In this regard, we assessed the efficiency of the María biosensor in detecting domiciliar infestations by *Triatoma dimidiata*.

A feature of the biosensor box reported by WISNIVESKI-COLLI et al.[14] is that the sensitivity increases with time up to 90 days and then stabilizes. Accordingly, in the present study, a cumulative increase in positivity was observed with readings performed at three monthly intervals in Santa Rosa and two in Quebrada Honda. For this reason, the cumulative values are preferred for expressing the results of biosensor performance.

Our results show that overall, the biosensor detected *T. dimidiata* more frequently than manual capture. However the superiority was significantly only for Quebrada Honda. It is possible that vector densities are lower in this place and that the sensor box is less affected by this than manual capture. Higher rates of positivity for the sensor box have also been reported by GARCIA-ZAPATA[4] in Brazil, and by SCHENONE[9] in Chile, both using the Gomez-Núñez sensor box for detection of *Triatoma infestans*.

In comparing further the performance of the biosensor against manual capture we found that the device detected the vector in 71.4% of positives houses by the other method, in both communities. However the biosensor was able to detect the vector in 39.3 and 41.4% of dwellings reported negatives by manual capture. Similarly, in Santiago del Estero, Argerntina, WISNIVESKI-COLLI et al.[14] found that the biosensor detected the presence of triatomines in 90% of households with intense infestation, 75% of the ones with moderate infestation and in 37.5% of houses negatives by manual capture. Also, in Brazil, GARCIA-ZAPATA[4] reported that in 110 infested houses the Gómez-Núñez biosensor detected the vector in 55.5%, while manual capture did it in 30.9%. As usually one method succeeds in detecting bugs where the other fails, it was not possible to use manual capture as a gold standard to determine the sensitivity of the biosensor. Moreover, some authors[4,5] consider both methods as complementary.

In our experience, many biosensor boxes were damaged or destroyed by the inhabitants, before the programmed examinations. This indicates the need of coupling an educative program to the implementation of the system.

From the economical standpoint, the biosensor surveillance system is a more viable alternative. WISNIVESKI-COLLI et al.[14] have reported that the method is four times less expensive than manual capture. Besides, in countries with an ongoing malaria control program as in Nicaragua, the system could easily be coupled with minimal investment.

The type of construction materials used for the house is one key factor in its colonization by triatomines[2,11,15,18]. We evaluated the housing conditions in the studied communities in order to assess the magnitude of interventions needed for a vector control program.

The predominant type of construction material differed between the areas. Adobe walls are more preferred in Santa Rosa whereas wood is more used in Quebrada Honda and Poneloya. However, unplastered adobe walls were more frequently infested by bugs in Santa Rosa than in Quebrada Honda, where the walls of canes or wood sticks had more bugs. On the other hand, straw roofing appeared to be more frequently infested in Quebrada Honda but not in Santa Rosa. One possible explanaton for these inconsistencies is the relatively small number of studied houses. In an extensive survey in Chile SCHENONE[10] found that the construction materials most favoring the presence of the triatomines were adobe or quincha walls, cane or straw roofs, abundance of crevices and dirty floors. Similarly, in Costa Rica, ZELEDON[18] showed that *T. dimidiata* is more associated with walls of mud or wood and with dirty floors. A second explanation to our results is that the presence of the bug in a house is the result of a complex interaction of structural factors as well as cultural ones. In fact, it has been demonstrated[5,11,15] that besides the quality of the dwelling, cultural attitudes and practices such as storage of harvested crops, presence of domestic animals inside the house or in the peridomicile, piling of domestic goods, have great influence in the colonization and persistence of the vectors, being therefore difficult to prove asociations with single variables.

The method we used for evaluation of housing condition was designed to measure the socioeconomic characteristics of individuals in health studies, but its way of integrating the parameters into one complex variable seemed to suit well to our purposes. In fact, the model revealed that Santa Rosa had the highest proportion of bad housing condition and Poneloya the lowest, which is consistent with the data on the house construction materials.

Our results showed that the bad houses were more frequently infested by triatomines than the regular ones. By comparison, in Bolivia[6], with a different methodology, vectors were found in 37.5 and 36.0% of bad and regular houses in Cochabamba but in Chuquisaca the respective rates were 77.7 and 93.8%.

The non-significant differences between the rates of infestation in the two categories of housing condition in our study might be attributed in part to the relatively high degree of homogeneity of the households in the communities and this is supported by the fact that we had to omit the category of good houses in our evaluation. Another possible explanation could be that, as was mentioned before, many other factors than the type of construction materials determine also the presence of triatomines in a house. We think that a more efficient model for evaluating the housing condition might be built by including more parameters.

In conclusion, our results show that in the studied areas, where *R. prolixus* was the principal vector, *Triatoma dimidiata* remains as the only vector species, infesting a large proportion of houses in the two of the studied rural settlements. Control measures are therefore needed in these areas and in this context the María biosensor would be an adequate and cost-effective method of surveillance capable of being easily implemented through the existing malaria antivectorial control program.

RESUMO

Vectores domesticos de la Enfermedad de Chagas en tres comunidades endémicas de Nicarágua.

Se efectuó una encuesta de vectores de la enfermedad de Chagas en tres comunidades endémicas de Nicaragua (Santa Rosa, Quebrada Honda y Poneloya) para medir las tasas de infestación domiciliar, evaluar la condición de las viviendas, y determinar la eficacia del biosensor María para detectar los vectores domésticos. Se seleccionaron un total de 184 casas y los vectores se buscaron por los métodos de captura manual estandarizada y biosensor. La única especie vectora encontrada en este estudio fue *Triatoma dimidiata*. De los chinches examinados el 50, 60 y 33%, en las respectivas comunidades, estaban infectados con *Trypanosoma cruzi*. Las tasas de infestación domiciliar, determinadas por captura manual y biosensor fueron respectivamente 48.3 y 54.2% en Santa Rosa, 29.8 y 51.2% en Quebrada Honda y en Poneloya 3.8 y 5.9%. El biosensor María detectó los vectores en el 71.4% de las casas positivas por la captura manual en dos de las comunidades, pero también fue capaz de detectar los chinches en el 39.3 y 41.4% de las casas donde la captura manual había sido negativa. La condición de la vivienda fue evaluada según tres parámetros estructurales; deste modo, en la primera comunidad 79.2% de las casas se clasificaron como malas y 20.8 como regulares; en la segunda 42.5% fueron malas y 57.5% regulares; mientras que en la tercera 62.5% fueron regulares. Las tasas de infestación domiciliar no diferieron mucho entre las diversas condiciones de vivienda. Nuestros resultados mostraron que el biosensor es tan eficiente como la captura manual y podría ser implementado en nuestro país como un método de vigilancia epidemiológica.

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