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HOUSE CONSTRUCTION, TRIATOMINE DISTRIBUTION, AND HOUSEHOLD DISTRIBUTION OF SEROREACTIVITY TO *TRYPANOSOMA CRUZI* IN A RURAL COMMUNITY IN NORTHEAST BRAZIL*†

KENNETH E. MOTT, TACITO M. MUNIZ, J. S. LEHMAN, JR., RODNEY HOFF, RICHARD H. MORROW, JR., TOME SILVA DE OLIVEIRA, ITALO SHERLOCK, AND C. C. DRAPER

Department of Tropical Public Health, Harvard School of Public Health, Boston, Massachusetts 02115, Nucleo de Pesquisas da Bahia, Fundação Oswaldo Cruz, Salvador, Bahia, Brazil, the Faculdade de Medicina, Federal University of Bahia (UFBa), Salvador, Bahia, Brazil, and the London School of Hygiene and Tropical Medicine, London, England

Abstract. Household distribution of seroreactivity to *Trypanosoma cruzi* in inhabitants was analyzed in relation to house construction and the distribution of *Panstrongylus megistus*, the principal domestic vector of Chagas' disease in a rural area in northeast Brazil. No children residing in mud-brick houses were seroreactive to *T. cruzi.* The highest rates of seroreactivity occurred in residents of unplastered mud-stick houses, and were twice as high as those found in persons living in mud-brick houses or plastered mud-stick houses. Two-thirds of seroreactive children in this area resided in unplastered mud-stick houses. Over 90% of the *P. megistus* infestations were found in mud-stick houses. Mud-brick houses had the lowest infestation rates of *P. megistus* and the lowest household rates of seroreactivity to *T. cruzi.*

In Latin America, the typical mud-stick rural dwellings are the principal foci of triatomine bug-mediated *Trypanosoma cruzi* transmission. The frequent presence of triatomine bugs in such houses was recognized as early as the 16th century.[1] The association between Chagas' disease and mud-stick houses was first noted when Carlos Chagas demonstrated that the triatomine bugs found in these dwellings transmitted the human disease which bears his name.[2] Recently, we showed that clustering of seroreactivity to *T. cruzi* in households occurred within an endemic area of stable *Panstrongylus megistus*-mediated *T. cruzi* transmission.[3] However, the quantitative relationship between house construction and presence or absence of *T. cruzi* infection in the household has not been established.

The degree of house infestation by triatomine bugs varies according to geographic area; from high density, as observed with domestic-adapted species such as *Triatoma infestans* or *Rhodnius prolixus*, to lower densities, found in endemic areas of *Panstrongylus megistus*, *Triatoma dimidiata*, or *Triatoma sordida*.[4] Although reports of geographic distribution of triatomine species abound in the scientific literature, the data have been rarely correlated with the rates of household *T. cruzi* infection. Such correlations might provide further insight about the efficiency of triatomine vectors and help to form a quantitative basis for Chagas' disease control programs.

The objective of this study was to determine the relationship between the prevalence of household seroreactivity to *T. cruzi*, the construction of the house and the prevalence of *P. megistus* infestation in a rural endemic area in northeast Brazil.

STUDY AREA

The study was conducted in the county (municipio) of Castro Alves, state of Bahia, a fertile tropical area near the bay, Bahia dos Todos os

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Address reprint requests to: Dr. Thomas H. Weller, Department of Tropical Public Health, Harvard School of Public Health, Boston, Massachusetts 02115.

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Santos, 187 km west of Salvador. The area has been described in previous reports.[3]

STUDY POPULATION

This study was completed on nine of 10 *fazendas*, i.e., geographic subunits traditionally defined by the local residents, which were previously described.[3]

The population of the nine study fazendas in September 1973 was 843 persons. This is a stable population of which 95% were born in Castro Alves.

METHODS

The household capture of the triatomine vector, *Panstrongylus megistus*, was performed on three occasions in the entire study area between August 1973 and May 1975. The timed collections were begun 15 min after 10% pyrethrum-in-talc dusting of the walls and lasted for 15 min (13.7 ± 4.24, $n = 155$; data from the first house search), (one-quarter manhour). The maximum density of *P. megistus* found on one of the three searches is reported here. Other evidence of *P. megistus* infestation such as triatomine eggs or dead bugs was reported as "noninfected *P. megistus*." The site of capture in the house was also noted, but is not reported in this study.

In the laboratory, the bugs were dissected, the rectal contents diluted with saline, and examined microscopically for the presence of *T. cruzi*. The finding of one infected bug in a house was considered as evidence of *T. cruzi* infection in that triatomine population. The rationale for this method is discussed later.

At the time of the first house visit, the construction of the house was recorded. The mud-stick (pau-a-pique) and mud-brick (alvenaria) construction are shown in Figure 1. Houses in a transition of improvement had some partially plastered rooms or walls and were classified as such. Some houses were of a mixed type; a portion of the house, usually the oldest, was mud-stick and the newer parts were of mud-brick construction. The sun-dried mud-bricks less often develop cracks as compared to the mud-stick walls. The roofs of the mud-stick houses were palm thatch and most of the mud-brick houses had tile roofs.

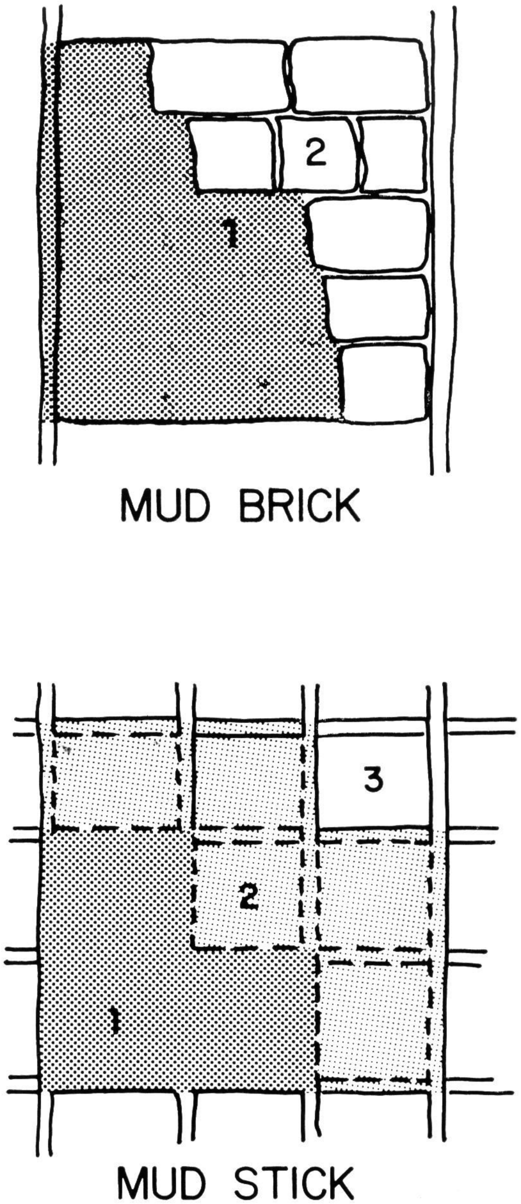

FIGURE 1. Typical house construction in northeast Brazil. Mud-brick construction is either unplastered (2) or plastered (1). Mud-stick construction begins with a wood stick framework (3) which is solidified with mud and may be unplastered (2) or plastered (1).

The procedure for serum collection, storage and the serological methods have been published.[3] Seroreactivity to *T. cruzi* was demonstrated by complement fixation titers of 1:8 or greater and/

TABLE 1

Distribution of P. megistus *according to house construction*

House construction	Number of houses	% of houses with evidence of *P. megistus*	Average
MUD-BRICK			
Plastered	21	0	10.0%
Unplastered	6	50.0	
Partial plastered	3	0	
MUD-STICK			
Plastered	20	20.0	55.5%
Unplastered	72	68.1	
Partial plastered	18	41.2	
MUD-BRICK and MUD-STICK	15	35.7	
TOTAL	155	45.5	

or indirect fluorescent antibody titers of 1:64 or greater.

RESULTS

Distribution of house construction

The majority (71.8%) of the houses in this area were of mud-stick construction. Only 19.2% of the houses were of mud-brick construction.

Distribution of house construction and P. megistus *infestation*

Of 167 houses in the study area, 155 were searched for *P. megistus* (Table 1). As shown in Table 1, *P. megistus* was found in 56% of the mud-stick houses. More importantly, 88.4% (61 of 69) of *P. megistus*-infested houses were of mud-stick construction. Only three unplastered mud-brick houses were infested with *P. megistus.* No *P. megistus* was found in the roofs.

Population seroreactivity to T. cruzi

Of 703 persons tested serologically, 324 (46.1%) were seroreactive for *T. cruzi.* These results have been published.[3] There were 239 children below 10 years of age who were offspring of the head of the household and had always lived with their parents in this study area. Of these children, 158 (66.1%) were tested serologically and 37 were seroreactive for *T. cruzi* antibody. Thirty-eight children, most of whom were born outside the study area and who were not directly related to the head of household, were excluded from this study because household exposure to *T. cruzi* could not be reliably determined.

Distribution of household seroreactivity to T. cruzi *according to house construction (Table 2)*

No children less than age 10 who resided in mud-brick houses were seroreactive to *T. cruzi.* All seroreactive children in this study area lived in mud-stick houses. The unplastered mud-stick houses sheltered 67.6% (25 of 37) of the children below 10 years of age who were seroreactive to *T. cruzi.* The prevalence rates of seroreactivity

TABLE 2

Distribution of seroreactivity to T. cruzi* *in household residents according to house construction*

House construction	Children <10 years tested	% children <10 years seropositive	Persons ≥10 years tested	% persons ≥10 years seropositive
MUD-BRICK				
Plastered	23	None	86	26.7
Unplastered	4	None	16	25.0
Partial plastered	3	None	12	25.0
MUD-STICK				
Plastered	22	13.6	75	49.3
Unplastered	67	37.3	239	64.4
Partial plastered	26	15.4	57	45.6
MUD-BRICK and MUD-STICK	13	38.5	60	38.3
TOTAL	158	23.4	545	49.5

* Seropositivity to *T. cruzi* was determined by the complement fixation (CF) test titers of 1:8 or greater. If CF was anticomplementary or not done, the indirect fluorescent antibody titer of 1:64 or greater was positive.

TABLE 3

Distribution of seroreactivity to T. cruzi* *in household residents according to house construction and* T. cruzi *infection of* P. megistus†

House construction	*P. megistus* status‡	Children <10 years tested	% children <10 years seropositive	Persons ≥10 years tested	% persons ≥10 years seropositive
MUD-BRICK					
Plastered, Unplastered, Partial plastered	*T. cruzi*-infected	0	–	0	–
	Non-infected	30	0	110	28.2
MUD-STICK					
Plastered	*T. cruzi*-infected	0	–	0	–
	Non-infected	20	15.0	68	47.1
Unplastered	*T. cruzi*-infected	25	76.0	86	82.6
	Non-infected	37	16.2	142	50.7
Partial plastered	*T. cruzi*-infected	8	12.5	9	77.8
	Non-infected	18	16.7	48	70.8
MUD-BRICK and MUD-STICK	*T. cruzi*-infected	5	60.0	11	45.5
	Non-infected	8	25.0	49	36.7
TOTAL	*T. cruzi*-infected	38	60.5	106	78.3
	Non-infected	113	17.5	417	29.7

* Seropositivity to *T. cruzi* was determined by the complement fixation (CF) test titers of 1:8 or greater. If CF was anticomplementary or not done the indirect fluorescent antibody titer of 1:64 or greater was positive.
† Does not include 7 children <10 years and 22 persons ≥10 years who resided in 12 houses which were not searched for triatomine bugs.
‡ *T. cruzi*-infected = presence of *T. cruzi* in rectal contents; non-infected = absence of *T. cruzi* in rectal contents, or only triatomine eggs or dead bugs present, or no *P. megistus* found.

in other residents (≥10 years of age) living in mud-brick houses of all types were low in contrast with the significantly higher rates in the same age group residing in mud-stick houses.* Of 32 seroreactive adult residents presently living in mud-brick houses, 30 had been born or formerly lived in a mud-stick house.

Distribution of household seroreactivity to T. cruzi *according to house construction and* P. megistus *infestation (Table 3)*

No seropositive children below 10 years of age resided in the two mud-brick houses where uninfected *P. megistus* was found. Three seropositive children were found in plastered mud-stick houses without *P. megistus*. In contrast, the highest prevalence rates were found in children living in unplastered mud-stick houses with *T. cruzi*-infected *P. megistus*.

The highest prevalence rates of seroreactivity to *T. cruzi* in persons age 10 years or older were also associated with unplastered mud-stick houses with infected *P. megistus*. In houses of all types, the household seropositive rate in older persons was highest if infected *P. megistus* were found.

* Chi-square test: $\chi^2 = 19.54$, df = 1, $P < 0.001$.

The distribution of household seroreactivity to T. cruzi *according to the number of* P. megistus *captured (Table 4)*

The prevalence of seroreactivity to *T. cruzi* in the household was proportionally higher in all residents according to the number of *P. megistus* captured, when at least one *P. megistus* was infected. The household capture of 10 or more *P. megistus*, of which at least one was infected with *T. cruzi*, was associated with seroreactivity in nearly all the residents.

DISCUSSION

The most important finding of our study was that no children residing in mud-brick houses were seroreactive to *T. cruzi*. In mud-brick houses, the seropositivity rate among adults was probably related to their prior exposure in mud-stick dwellings.

TABLE 4
Household seroreactivity to T. cruzi* *according to density of* Panstrongylus megistus *infestation*†

Density of *P. megistus* house infestation	Household children < 10 years No. tested	% Pos.	Household persons >10 years No. tested	% Pos.
Absent	70	10.0	272	42.6
Non-infected *P. megistus*	22	27.3	60	48.3
1–3 *P. megistus*	16	37.5	33	63.6
4–6 *P. megistus*	11	63.6	35	77.1
7–9 *P. megistus*	5	80.0	18	83.3
≥10 *P. megistus*	6	100.0	23	91.3
Total	130		441	

* Seropositivity to *T. cruzi* was determined by the complement fixation (CF) test titers of 1:8 or greater. If CF was anticomplementary or not done, the indirect fluorescent antibody titer of 1:64 or greater was positive.
† Not included are serology results of 104 persons ≥10 years of age and 28 children <10 years of age from 21 houses with only *P. megistus* eggs or dead bugs, or from 12 houses which were not searched. Average search time was one-quarter man hour.

Our data document that high rates of seroreactivity in children were associated with mud-stick houses and the presence of infected *P. megistus*. In a previous study in the same area, seropositive children were shown to be a good indicator of a high rate of household seroreactivity to *T. cruzi*.[3] The finding of infected *P. megistus* in a house indicates a high risk of *T. cruzi* infection in that household.

Congenital transmission of *T. cruzi* undoubtedly occurs in the endemic area; however, documentation of this event in the rural setting has been rare. This mode of transmission was implied by the presence of three seroreactive children from plastered mud-stick homes without *P. megistus* whose mothers were seropositive and whose fathers were seronegative. Longitudinal studies of seroreactive mothers in endemic and urban areas will clarify the frequency and mechanism of this event.[5]

In Castro Alves *P. megistus* was found only in houses; no sylvatic captures of *P. megistus* have been reported in this region of Bahia.[6] In other endemic areas such as in the State of São Paulo where *P. megistus* participates in both the domiciliary and sylvatic *T. cruzi* life cycle,[7] it also appears that the mud-stick house was the major focus of human *T. cruzi* transmission. Fonseca reported a state-wide survey from São Paulo in which the most common domestic triatomine species collected were *T. infestans*, *T. sordida*, and occasionally *P. megistus*.[8] Although only 28% of the mud-stick houses were infested, 50% of all the triatomine bugs captured were found in such houses. More importantly, 82% of all *T. cruzi* infected bugs were found in mud-stick houses.

In this study, multiple searches increased the sensitivity of detecting infestation with *P. megistus*. In the endemic areas such as Castro Alves, low density *P. megistus* infestations have been the rule rather than the exception.[6] In addition, public awareness that triatomine vectors transmit disease has been accompanied by increased use of insecticides by the residents which may have further reduced an already low *P. megistus* population. Any field worker who has searched houses for triatomine vectors recognizes the limitations which include cooperation of the residents, the technician's skill at capture and the accessibility of the bugs. Thus, although a house can be declared "infested" if one bug is found, a negative search does not necessarily infer their absence. Only complete demolition and meticulous searching of a house can determine if it is not infested.[9]

Our study shows that the finding of *T. cruzi*-infected *P. megistus* in a house was associated with a higher rate of seroreactivity to *T. cruzi* in children than in households in which no infected *P. megistus* was found. This correlation indicates the importance of determination of *T. cruzi* infection in captured bugs. Detection of *T. cruzi* infection in the triatomine vector involves a tedious time-consuming method and requires a skillful microscopist. A concentration method has been suggested,[10] but requires a centrifuge, which may not always be available. In spite of these limitations, our study has shown a correlation between the presence of *T. cruzi*-infected bugs in houses and infected residents, especially children.

About 90% of the *P. megistus*-infested houses were of mud-stick construction in this rural community. It has been suggested for control programs that these houses be demolished and replaced by structures with solid, smooth walls that do not crack.[11,12] Since these houses are responsible for 90% of the house infestations in this endemic area, after systematic residual insecticide spraying or construction modification a remarkable reduction in infestation in the community could be expected.

Currently new strategies are being developed to combat Chagas' disease.[13,14] This study suggests that in areas where *P. megistus* is the domestic vector, public health strategies should take the following into account:

1. *P. megistus* is found predominantly in mud-stick houses. These houses should be plastered or replaced as part of concerted control programs.

2. Mud-brick houses, which can be constructed with local materials and expertise, should be encouraged; this type of house reduces the risk of *P. megistus* infestation, thus preventing infection of the children.

3. Seroreactivity in children is an excellent index of household infection in areas with stable *P. megistus*-mediated *T. cruzi* transmission. Children born in and residing in mud-stick houses infested with *P. megistus* have a high rate of seroreactivity.

4. Surveys of the distribution of triatomine bugs in houses should include the number of bugs captured per man hour and examination for *T. cruzi* infection.

5. In houses with any infected *P. megistus*, the household rate of seropositivity to *T. cruzi* positively correlates with the number of bugs captured.

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