

# Evaluation of the Chagas' Disease Vector Control Program in Minas Gerais, Brazil, with Special Reference to *Triatoma sordida*<sup>1</sup>

LILÉIA DIOTAIUTI,<sup>2</sup> OSMAR RIBEIRO DE PAULA,<sup>3</sup>  
PATRÍCIA LIMA FALCÃO,<sup>4</sup> & JOÃO CARLOS PINTO DIAS<sup>5</sup>



As of 1979, data gathered by the Chagas' Disease Control Program (CDCP) in the Brazilian state of Minas Gerais indicated that *Triatoma infestans* was the Chagas' disease vector most commonly found in and around human dwellings. A decade later, however, this picture had changed, presumably as a result of control efforts; few specimens of *T. infestans* were collected; and *Triatoma sordida* had become the most commonly collected vector insect. The aim of the work reported here was to assess the effectiveness of the CDCP in Minas Gerais in 1979–1989, with special reference to *T. sordida*.

For this purpose, 1979–1989 triatomine collection data were reviewed for the two Minas Gerais health districts (Montes Claros and Uberaba) believed to have the heaviest *T. sordida* infestations. In addition, 1987 data from a serologic survey for human *Trypanosoma cruzi* infections in seven municipalities of these regions were compared with earlier (1978) serologic data from the same locales.

In general, the triatomine collection data documented the precipitous decline of *T. infestans* in and around human dwellings. They also indicated that while the *T. sordida* collections had remained stable (in Uberaba) or increased markedly (in Montes Claros), there had been no great upsurge in the numbers of *T. sordida* collected inside dwellings. It was concluded that control measures were preventing extensive house reinfestations in both Montes Claros and Uberaba; that the situation in Uberaba was relatively stable; and that the marked increase in *T. sordida* populations around homes in Montes Claros was associated with forest clearing and changing settlement patterns. A marked drop in the incidence of human *T. cruzi* infections, indicated by comparison of the 1978 and 1987 serologic surveys, provided further supporting evidence that the control program activities carried out in this period were effective.

At the beginning of the 1980s, the apparent prevalence of human Chagas' disease cases in Minas Gerais State (obtained by surveying a rural population sample in 717 municipalities) was found to be 0.8% (1). Official reports at the time indicated that *Triatoma infestans* accounted for 64.6% of the triatomines

captured under the National Health Foundation's Chagas' Disease Control Program (CDCP), with 84.4% of that total being captured inside dwellings. The infection rate of these bugs with *Trypanosoma cruzi* was 10.3%.

*Triatoma sordida* accounted for 28.6% of the triatomine captures. Three-quarters

<sup>1</sup>This article will also be published in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, Vol. 118, No. 1, January 1995.

<sup>2</sup>René Rachou Research Center, FIOCRUZ, C.P. 1743, CEP 30.190, Belo Horizonte, Minas Gerais, Brazil; and Minas Gerais Federal University, Department of Parasitology, Belo Horizonte, Minas Gerais, Brazil.

<sup>3</sup>National Health Foundation, Ministry of Health, Belo Horizonte, Brazil.

<sup>4</sup>René Rachou Research Center, Belo Horizonte, Brazil.

<sup>5</sup>René Rachou Research Center, Belo Horizonte, Brazil; and Minas Gerais Federal University, School of Medicine, Department of Clinical Medicine.

(75.6%) of these insects were captured in areas around dwellings, and 2.4% were found infected with *T. cruzi*.

The third most common species in terms of numbers captured was *Panstrongylus megistus*, which accounted for 18.5% of the captures. Most (70.7%) of these bugs were captured in areas around residences, and 2.0% were found infected with *T. cruzi*.

*T. sordida*, a species whose endemic center is Brazil's densely vegetated scrublands ("cerrado") (2), is widespread throughout the country. Indeed, in terms of post-spray captures made under the CDCP, nationwide 1983-1985 observations indicated that *T. sordida* was then the most commonly captured triatomine species in the country.<sup>6</sup> Despite this, at the time little was known of this triatomine's role in the epidemiologic profile of Minas Gerais as a vector of Chagas' disease in humans.

As part of its basic working methodology, once or twice a year the CDCP (3) performs residual insecticide sprayings of triatoma-infested homes and their immediate surroundings until the percentage of infested households falls below 5%, and until no *T. infestans* are observed in areas where the occurrence of this species has been noted. A system of epidemiologic surveillance is then instituted whereby National Health Foundation workers spray triatomine foci identified by household residents, who provide notification of such foci through a local information network.

Until 1985, the CDCP sprayed with benzene hexachloride (BHC). In 1984, however, this pesticide was banned for

agricultural use, making production for public health purposes economically impractical. In searching for alternative insecticides, a series of tests was run using pyrethroids, which were found superior to BHC (4)<sup>7</sup> in terms of being biodegradable, protecting the home for longer periods of time, offering greater knock-down power, having low toxicity for humans and domestic animals,<sup>8</sup> leaving no residue on walls, and being odorless (which helps ensure better acceptance by the population). Therefore, pyrethroids were firmly incorporated into the CDCP (3).

The purpose of the present study was to assess the effectiveness of the CDCP in Minas Gerais between 1979 and 1989, with special reference to *T. sordida*, and on that basis to propose alternative or additional elements for the program.

## MATERIALS AND METHODS

Secondary data from the CDCP (National Health Foundation, Minas Gerais) were used to calculate the "capture index," defined as follows:

$$\text{Capture index} = \frac{\text{No. of triatomines captured}}{\text{No. of households surveyed during the period}} \times 100$$

<sup>7</sup>Dias JCP, Chedvilli JM, Vasconcelos JVA. *Emprego da decametrina contra triatomíneos brasileiros em área endêmica*. Paper presented at the XVII Congress of the Brazilian Tropical Medicine Association, Caldas Novas, Brazil, 1981; and Dias JCP, Benedito VA, Vasconcelos JA, Diotaiuti L. *Ensaio de campo com permetrina e cipermetrina contra triatomíneos em Minas Gerais, Brasil*. Paper presented at the XX Congress of the Brazilian Tropical Medicine Association, Salvador, Brazil, 1984.

<sup>8</sup>Dias JCP, Benedito VA, Vasconcelos JA, Diotaiuti L. *Ensaio de campo com permetrina e cipermetrina contra triatomíneos em Minas Gerais, Brasil*. Paper presented at the XX Congress of the Brazilian Tropical Medicine Association, Salvador, Brazil, 1984.

<sup>6</sup>Dias JCP, Silveira AC, Cunha RA. *Índices triatomínico-tripanosômicos observados no Programa de Controle da Doença de Chagas (SUCAM) em ambiente domiciliar, no Brasil, de 1983 a 1985*. Paper presented at the XXIV Congress of the Brazilian Tropical Medicine Association, Manaus, Brazil, 1988.

Since the regions of the Montes Claros and Uberaba health districts (shown in Figure 1) were found to be infested predominantly by *T. sordida* in 1989, they were selected as the subjects of a longitudinal study covering the 1979–1989 period. A new stage of the CDCP had been launched in the “Triangulo Mineiro” (the western area of Minas Gerais State between the Paranaíba and Grande Rivers corresponding roughly to the area of Uberaba) in 1976 and in Montes Claros in 1979.

To assess the impact of the CDCP, serologic surveys were carried out in six municipalities within the Triangulo Mineiro (Itapagipe, Conceição das Alagoas, São Francisco de Sales, Capinópolis, Douradoquara, and Cachoeira Dourada) and in one municipality of northern Minas Gerais (Mato Verde). Sample size determination followed the guidelines presented in a WHO document (5), using prevalences published in 1984 (1).

Blood was collected in 1987 by fingertip puncture and absorption onto filter paper. The samples were subsequently processed by indirect immunofluorescence (6), considering as positive a titer of 1:40, the same used in the National Serologic Survey (1). In all, blood was

collected from 2 135 subjects in the Triangulo Mineiro and 132 in Mato Verde.

## RESULTS

Table 1 shows the numbers of triatomines captured by the CDCP in Minas Gerais in 1979 and 1989. As may be seen, after this decade of CDCP activity the relative proportions of captured *T. infestans*, *T. sordida*, and *P. megistus* had changed dramatically.

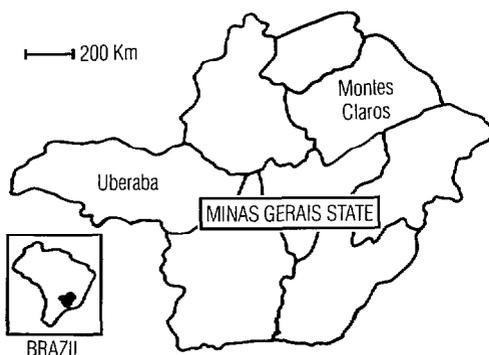
The response of these triatomines to spraying in Montes Claros and Uberaba is shown in Figure 2. In Montes Claros (northern Minas Gerais), the overall capture index for *T. infestans* plummeted from 46.5 in 1979 to levels of 5 or less from 1982 onward. This was accompanied by parallel drops in the household capture index and the overall infection rate of the insects with *T. cruzi*.

In Uberaba (Triangulo Mineiro), the overall capture index for *T. infestans* was 0.9 in 1979 (Figure 2D). This index fell to virtually zero from 1984 onward, reflecting captures of 19, 5, 5, 7, 5, and 10 triatomines per year, respectively, from 1984 through 1989.

The observed *P. megistus* population also fell sharply, especially in Montes Claros (Figure 2B). As may be seen, the overall capture index in Montes Claros fell from 2.6 in 1979 to 0.2 in 1989. Regarding household captures, the index dropped from 1.0 in 1979 to values approaching zero in 1989, with a corresponding decrease in the overall infection rate of the insects with *T. cruzi*. These data indicate some residual presence of *P. megistus* remained in 1989, mainly in areas outside but near homes.

The observed *P. megistus* population fell more slowly in Uberaba (Figure 2E) than in Montes Claros, though the overall capture index did eventually decline to 0.8 (from 2.4 in 1979) and the household capture index dropped from 1.0 to 0.1. There

**Figure 1.** A map of Minas Gerais State showing the administrative divisions of the National Health Foundation, including the districts of Montes Claros and Uberaba.



**Table 1.** Triatomine captures in Minas Gerais State in 1979 and 1989 by the National Health Foundation, Ministry of Health, Coordinating Office for Minas Gerais, Chagas' Disease Control Program.

Year	Species	No. captured	Insect specimens		
			No. examined	Positive	
				No.	(%)
1979	<i>Triatoma infestans</i>	55 713	47 401	4 873	(10.3)
"	<i>T. sordida</i>	30 404	25 330	597	(2.4)
"	<i>Panstrongylus megistus</i>	19 644	13 072	257	(2.0)
"	<i>Rhodnius neglectus</i>	365	245	0	—
"	<i>T. pseudomaculata</i>	240	211	0	—
"	<i>T. vitticeps</i>	28	28	0	—
"	<i>P. geniculatus</i>	20	19	0	—
"	<i>T. brasiliensis</i>	1	1	0	—
1979 total		106 415	86 307	5 727	(6.6)
1989	<i>T. sordida</i>	124 512	80 960	388	(0.5)
"	<i>P. megistus</i>	8 254	7 136	139	(1.9)
"	<i>T. pseudomaculata</i>	1 339	923	11	(1.2)
"	<i>R. neglectus</i>	1 254	760	3	(0.4)
"	<i>T. vitticeps</i>	805	580	21	(3.6)
"	<i>T. infestans</i>	503	298	12	(4.0)
"	<i>P. geniculatus</i>	139	57	5	(8.8)
"	<i>T. brasiliensis</i>	19	2	0	—
"	<i>P. diasi</i>	10	0	0	—
"	<i>T. melanocephala</i>	2	1	0	—
"	Unidentified	69	10	3	(30.0)
1989 total		136 806	90 727	582	(0.6)

Source: National Health Foundation, Ministry of Health; Coordinating Office for Minas Gerais (Chagas' Disease Control Program).

was also a consistent rise in the percentage of *P. megistus* infected with *T. cruzi*, from 2.1% in 1979 to 6.9% in 1987, before that percentage declined to 2.6% in 1989. This increase in the natural *T. cruzi* infection rate was observed in both adults and nymphs.

Meanwhile, the observed *T. sordida* population in Montes Claros shot upward, the overall capture index rising from 2.7 in 1979 to levels around 30 during 1987–1989 (Figure 2C). However, the household capture index remained relatively low, and the initial years of the CDCP saw a significant drop in the natural *T. cruzi* infection rate that persisted to a greater or lesser degree through 1989.

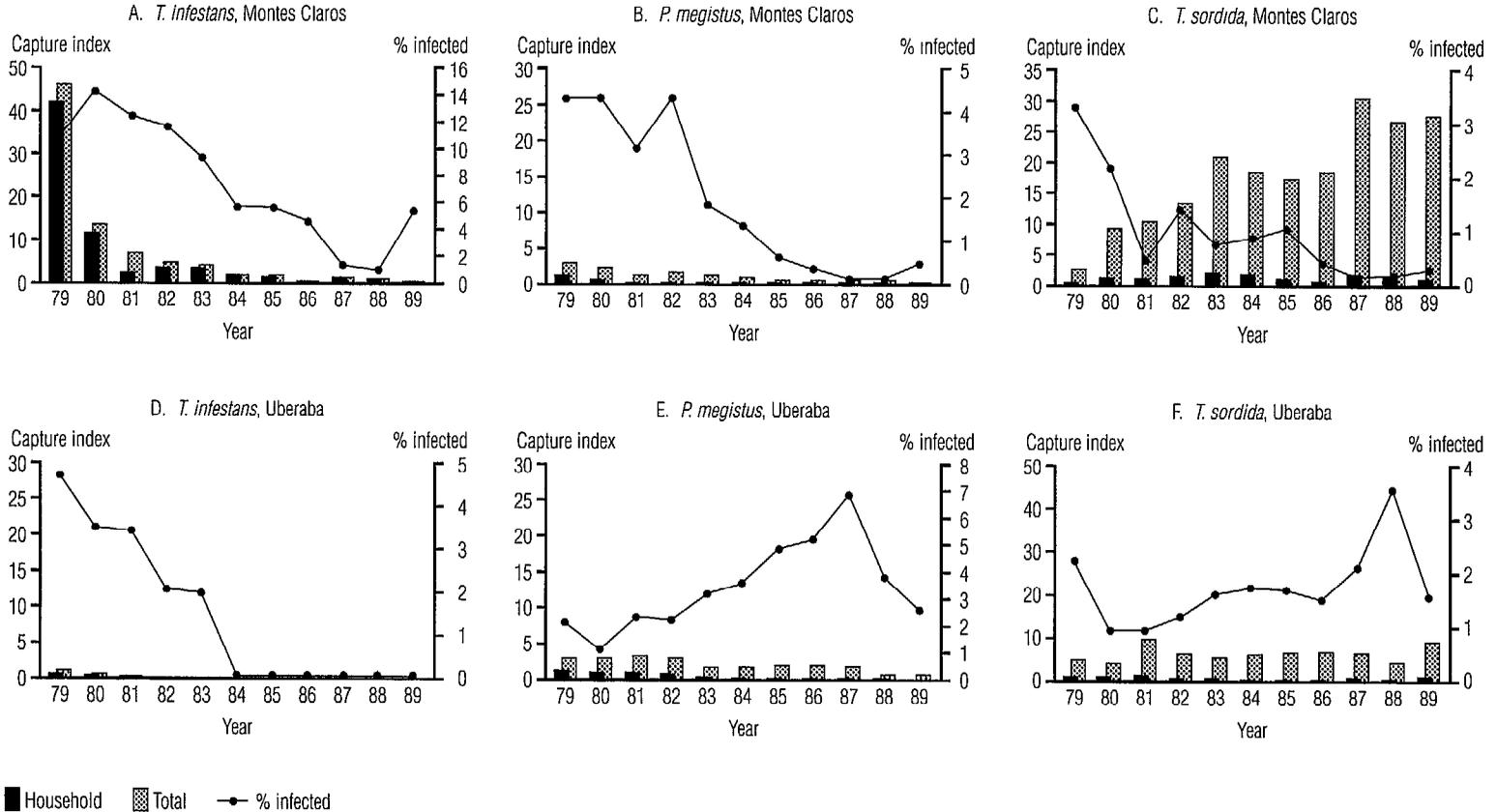
In Uberaba this marked overall growth of captured *T. sordida* (Figure 2F) was not

observed, and the household capture index showed no long-term trend toward household invasion by this species over the study period.

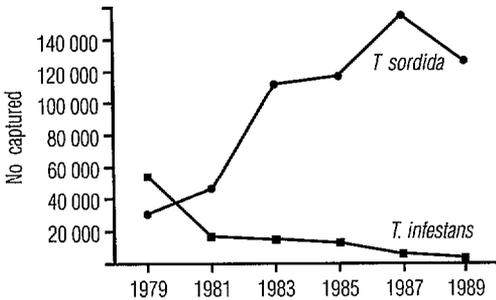
For Minas Gerais as a whole, the data in Figure 3 show a 68.8% drop in the number of *T. infestans* specimens captured in 1981 as compared to 1979, following the first two years of spraying. However, the overall *T. sordida* capture index rose, slowly at first and then faster, mainly as the result of foci located in the immediate vicinity of dwellings rather than in them—a situation contrasting with *T. infestans*' predilection for infesting dwellings.

Regarding the aforementioned serologic survey of 1987, the prevalence of Chagasic infection in 2 135 subjects from

**Figure 2.** Household and total (household plus peridomiciliary) capture indexes, and *T. cruzi* infection rates found for the three species of triatomines captured most frequently by the Chagas' Disease Control Program (CDCP) in the Minas Gerais districts of Montes Claros and Uberaba, 1979–1989. Black bars show household capture indexes, stippled bars show total capture indexes, and dots show rates of *T. cruzi* infection. *Source:* National Health Foundation, Coordinating Office for Minas Gerais.



**Figure 3.** Numbers of *T. infestans* and *T. sordida* triatomines captured in Minas Gerais under the National Health Foundation's Chagas' Disease Control Program (CDCP), 1979–1989.

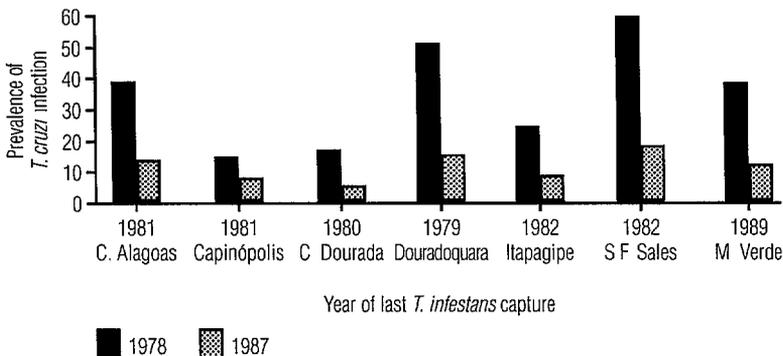


six municipalities in the Triângulo Mineiro was found to be 11.9%. The prevalence was quite age-specific, however, ranging from 0.4% among children under 10 years of age to 32.9% among subjects over 50.

A similar pattern was found in the municipality of Mato Verde, where the prevalence of Chagasic infection among the 132 people examined was found to be 11%. Only 1 child under 10 years old (out of 47 children examined in this age group) was found to be infected.

Figure 4 compares these 1987 data for each municipality with earlier (1978) data from the National Serologic Survey (1).

**Figure 4.** Human prevalences of *T. cruzi* infection in seven study municipalities in 1978 and 1987, as indicated by serologic surveys. The most recent year of *T. infestans* capture in each municipality is shown below the bars.



The years of the most recent *T. infestans* captures in each municipality are shown at the bottom of the chart.

## DISCUSSION AND CONCLUSIONS

According to a 1940 survey done in Minas Gerais State (7), *P. megistus* accounted for 79.8% of the triatomines captured, *T. sordida* for 9.7%, and *T. infestans* for 9.3%. The respective rates of *T. cruzi* infection in these insects were found to be 41.3%, 6%, and 15%. As of 1951 the situation did not appear to have changed much (8), aside from a noteworthy spread of *T. infestans* into the western part of the state.

Around the end of the 1970s, National Health Foundation data showed that *T. infestans* had spread up to the northern border of Minas Gerais; at that point (see Table 1) this bug accounted for nearly twice the number of triatomine captures as did the next most commonly captured species, *T. sordida* (28.6%), which in turn had pushed *P. megistus* down into third place on the list (18.5%). No major changes were noted in the geographic distribution of *T. sordida* within the state.

During the 1980s, efforts to control *T. infestans* in Minas Gerais achieved the same

success observed in São Paulo (9). The capture index for this species fell off sharply, accompanied by a drop in the percentage of infected bugs. Dias (10) attributes this to elimination of household infestations and the resulting lower household density of the vector. Also in the 1980s, reduction of acute Chagas' disease cases and *T. cruzi* infections in young patients—undoubtedly the major source of infection for household triatomines—led to a drop in the overall natural infection rate of these insects. The lower 1979 capture index for *T. infestans* in Uberaba as compared to Montes Claros (see Figures 2A and 2D) is explained by the fact that the spraying program in Uberaba had been launched in 1976, several years earlier than in Montes Claros.

A similar response to the control program was seen in the numbers of *P. megistus* collected in Uberaba and Montes Claros. Early studies had shown that these triatomines adapted well to the household environment, especially in the northern part of the state (7, 8, 11). It was this mainly domestic population that declined quickly in response to spraying, yielding the lower capture indices shown by National Health Foundation data (see Figures 2B and 2E). It is not surprising, however, that the data also revealed a residual presence of this triatomine, which is native to Minas Gerais and has made persistent attempts to move into and colonize new habitats.

Regarding infection with *T. cruzi*, infection of *P. megistus* in Montes Claros displayed a downward trend—easily explainable by removal of this species from the artificial habitats that were the main targets of the National Health Foundation program. In Uberaba, however, the rates of *T. cruzi* infection detected in *P. megistus* rose. We feel that if there had been higher infection rates in captured adults than in captured nymphs, this could have indicated an increased in-

vasion of artificial habitats by *T. cruzi*-positive triatomines from wild habitats. However, the available data revealed an increase in the infection rates of both adults and nymphs. This noteworthy observation, which has also been reported from Bahia State by Italo Sherlock (Gonçalo Muniz Center, FIOCRUZ, 1993, personal communication), merits further investigation.

Turning to *T. sordida*, the Montes Claros District showed a marked increase in *T. sordida* captures in peridomestic areas. Inside the home, this triatomine did not show—at any time during the period analyzed—any of the significant densities that have been observed by Garcia Zapata at Mambá in Goiás State (12). (Garcia Zapata noted an increase of *T. sordida* inside dwellings between 1985 and 1990, leading to a warning of imminent colonization by the species in the near future if control measures were discontinued.)

The lower response of outdoor triatomine populations to control measures is to be expected. For one thing, insecticides deteriorate more rapidly in this environment (13). Also, spraying the entire area around a house is a major undertaking that involves removing all the items accumulated there which can facilitate survival of triatomines in inaccessible hiding places. Active or passive reinvasion by wild specimens is another possibility to be considered; and easy access to food renders areas around dwellings auspicious for *T. sordida* colonization, especially when a continuous food supply is offered by such activities as keeping chickens in coops (14).

In the Triângulo Mineiro (Uberaba area), the maximum level of *T. sordida* control attainable with the National Health Foundation's current methods appears to have been reached. Although more land is being used for planting crops and producing charcoal, livestock raising continues to be the region's main economic

activity (15). Ecologically, the region underwent modification some time ago and is currently experiencing fewer interventions than the northern areas. As a result, less pressure is being exerted upon wild *T. sordida* populations.

This explains the greater stability of Uberaba's *T. sordida* collection rates over the course of the study period. Montes Claros, on the other hand, has been the site of many new colonization projects, with forest clearing and expansion of cultivated areas (14). These projects have been very irregular, resulting in uncontrolled environment interventions (16). As a result, habitat destruction is forcing wild triatomines such as *T. sordida* to seek survival alternatives. Despite this circumstance, *T. sordida* has not established a marked household presence in the northern part of the state—thanks to the continued efforts of the CDCP in the area and also to the fact that spraying protects homes for relatively long periods of time (13).

The comparison between 1987 prevalences of Chagasic infection among humans in seven municipalities (see Figure 4) and those found in 1978 by the National Serologic Survey (1) points to a marked drop over this period. The fact that the decline was roughly concurrent with the *T. infestans* control activities described would seem to reinforce data indicating that this insect is the principal vector of Chagas' disease in the region.

One conclusion to be drawn from the reported data is that the CDCP has been successful in areas infested predominantly by *T. sordida* under the peridomestic colonization conditions we have observed. According to Martins (17), "human infection in an endemic form is only possible in regions where domiciliary triatomines exist." The CDCP has prevented any such colonization, or else has kept household densities at very low levels, and so has achieved its goal. Under these conditions, *T. sordida's* role in the

transmission of human Chagas' disease is currently irrelevant in Minas Gerais, as has also been observed in São Paulo (9) and Mambai (12), a circumstance made possible at great cost in terms of human effort and monetary expense (4, 18).

It should also be noted that Brazil's experience in working against Chagas' disease has confirmed the effectiveness and workability of the epidemiologic surveillance system employed (19). However, bearing in mind the relationship that exists between peridomestic infestation and peridomestic order, it seems clear that this system should include, besides eradication of triatomine foci, establishment of a process of discussion with the population that over the long run will inculcate a conscious change in behavior encouraging cleanliness in and around the home (20).

*Acknowledgments.* We would like to thank the Parasitology Laboratory at the Ezequiel Dias Foundation (Fundação Ezequiel Dias—FUNED) for performing the serologic tests, Dr. Carlos Maurício Antunes for his assistance with sample size determination for the serologic survey, and the National Health Foundation for granting us access to archives as well as for its invaluable support in the study areas.

## REFERENCES

1. Camargo ME, Silva GR, Castilho EA, Silveira AC. Inquérito sorológico da prevalência da infecção chagásica no Brasil, 1975–1980. *Rev Inst Med Trop São Paulo* 1984; 26(4):192–204.
2. Forattini OP. Biogeografia, origem e distribuição da domiciliação de triatômíneos no Brasil. *Rev Saúde Pública* 1980;14:265–299.
3. Dias JCP. Control of Chagas' disease in Brazil. *Parasitol Today* 1987;3(11):336–341.
4. Pinchin R, Oliveira Filho AM, Fanara DM, Gilbert B. Ensaio de campo para avaliação

- das possibilidades de uso da decatrina (OMS 1988) no combate aos triatomíneos. *Rev Bras Malariol Doenç Trop* 1980;32:36-41.
5. World Health Organization, Epidemiological and Statistical Methodology Unit. *Sample size determination: a user's manual*. Geneva: WHO; 1986. (Document HST/86.1).
  6. Camargo ME. Fluorescent antibody test for the serodiagnosis of American trypanosomiasis: technical modification employing preserved culture forms of *Trypanosoma cruzi* in a slide test. *Rev Inst Med Trop São Paulo* 1966;8:227-234.
  7. Martins AV, Versiani V, Tupinambá A. Estudos sobre a tripanosomíase americana em Minas Gerais, Brasil. *Mem Inst Oswaldo Cruz* 1940;35(2):285-300.
  8. Martins AV, Versiani V, Peres JN. Distribuição geográfica dos triatomíneos e seus índices de infecção pelo *T. cruzi* no Estado de Minas Gerais. *Arq Saúde Pública* 1951;2(1):63-79.
  9. Souza JMP, Wanderley DMV, Buralli GM, Andrade JCR. Consolidation of the control of Chagas' disease vectors in the State of São Paulo. *Mem Inst Oswaldo Cruz* 1984;79(suppl):125-131.
  10. Dias JCP. *Doença de Chagas em Bambuí, Minas Gerais, Brasil: estudo clínico-epidemiológico a partir da fase aguda, entre 1940 e 1982*. Belo Horizonte: Universidade Federal de Minas Gerais; 1982. [Doctoral dissertation].
  11. Pellegrino J. Novos dados sobre a distribuição de triatomíneos e sua infecção pelo *T. cruzi* no Estado de Minas Gerais (Brasil). *Mem Inst Oswaldo Cruz* 1950;48:639-667.
  12. Zapata MTAG. *Controle da doença de Chagas com inseticidas e participação comunitária em Mambá, Goiás*. Belo Horizonte: Universidade Federal de Minas Gerais; 1990. [Doctoral dissertation].
  13. Diotaiuti L, Pinto CT. Suscetibilidade biológica do *Triatoma sordida* e *Triatoma infestans* a deltametrina e lambdacyhalotrina em condições de campo. *Rev Soc Bras Med Trop* 1991;24(3):151-155.
  14. Diotaiuti L, Carneiro M, Loiola CCP, Silveira Neto HV, Coutinho RM, Dias JCP. Alternativas de controle do *Triatoma sordida* no Triângulo Mineiro: I, borrifação parcial (intradomicílio) no município de Douradoquara, Minas Gerais, Brasil. *Rev Soc Bras Med Trop* 1988;21(4):199-203.
  15. Fundação Instituto Brasileiro de Geografia e Estatística. *Censo agropecuário*. Rio de Janeiro: FIBGE; 1985.
  16. Muls NB. *Jaíba: uma análise sociológica; subsídios para reorientação do projeto*. Belo Horizonte: Secretaria do Planejamento; 1985: annex 03/05. [Mimeographed document].
  17. Martins AV. Epidemiologia da doença de Chagas. In: Cançado JR. *Doença de Chagas*. Belo Horizonte: Imprensa Oficial; 1968:223-237.
  18. Oliveira Filho AM. Cost-effectiveness analysis in Chagas' disease vectors' control interventions. *Mem Inst Oswaldo Cruz* 1989;84(suppl IV):409-417.
  19. Schofield JC, Dias JCP. A cost-benefit analysis of Chagas' disease control. *Mem Inst Oswaldo Cruz* 1991;86(3):285-295.
  20. Jorg ME. La modificación del biotopo perihabitacional en la profilaxis de la enfermedad de Chagas. *Rev Soc Bras Med Trop* 1989;22:91-95.