Chagas Disease Vector Control in Central America

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As the Southern Cone Initiative proceeds steadily towards eradication of Triatoma infestans, *there is increasing interest in applying similar approaches to control Chagas disease vectors in Mexico, Central America and countries of the Andean Pact. Here, Chris Schofield and Jean-Pierre Dujardin discuss the technical feasibility of such an approach.*

The Southern Cone Initiative against Chagas disease was formalized in 1991 with the stated objectives of interrupting transmission of *Trypanosoma cruzi* by elimination of all domestic and peridomestic foci of the main vector, *Triatoma infestans*, suppression of other vectors, and mandatory screening of blood donors to reduce the risk of transfusional transmission[1]. Since then, the countries of the Southern Cone (Argentina, Bolivia, Brazil, Chile, Paraguay, Uruguay) have invested over US$200 million in the programme. Over 1.8 million houses have been treated with modern pyrethroids to eliminate the vectors, and obligatory screening of blood donors has been implemented in all countries except Bolivia.

The results to date have been spectacular, with transmission halted over vast areas of Argentina, Brazil, Chile and Uruguay, as well as parts of southern Bolivia and eastern Paraguay. The economic return of the programme, originally predicted to be just over 14% (Ref. 2), has recently been calculated at over 64% in a post-intervention study in northwestern Argentina[3].

An important question, therefore, is to what extent this experience can be implemented in other countries of Latin America where Chagas disease remains a serious problem (Fig. 1; Table 1). The keys to this – to judge from the Southern Cone – lie partly in the political priority accorded by each of the endemic countries, and partly in the biological characteristics of the main vector species. In spite of recent advances[4], treatment of Chagas disease remains impractical on a large scale, and vaccines are not available. The biological characteristics of the triatomine bug vectors, however, make them highly vulnerable to control through modern intervention methods using residual formulations of pyrethroid insecticides. The bugs are relatively slowly reproducing (1–2 generations per year) with a consequently low rate of genetic rearrangement. They tend to have low population variability, together with other genetic and demographic characteristics, rendering it difficult to select for attributes such as insecticide resistance[5]. Most importantly, the main vector species such as *T. infestans* in the Southern Cone region are almost entirely confined to domestic and peridomestic habitats, with a relatively low capacity for active dispersal. Although they are extremely well adapted to stable domestic situations (exhibiting strong *K*-selection, in contrast to the *r*-selection of, say, mosquitoes) they are less well adapted to respond to instabilities, such as the changes implied by vector-control interventions.

Historical reconstruction, combined with genetic analysis, indicates that *T. infestans* originated in central Bolivia, where silvatic bugs can occasionally be found among rockpiles in association with wild guinea-pigs. From there, it seems to have been spread in association with human migrations, especially since the turn of this century. Outside of its presumed origin in central Bolivia, *T. infestans* seems entirely domestic or peridomestic, and recent genetic studies indicate incipient separation between the original silvatic forms and neighbouring domestic populations[6].

Outside the Southern Cone region, however, the main vector of Chagas disease is *Rhodnius prolixus* (well known to students of insect physiology from the pioneering work of Sir Vincent B. Wigglesworth and others). *Rhodnius prolixus* is a species of some taxonomic complexity, with marked similarities to several other species such as *R. robustus*, *R. neglectus* and *R. nasutus*. All these are recorded from palm tree crowns, which have long been thought to represent their original habitat. But there is increasing evidence to suggest that *R. prolixus* may in fact be no more than the domestic derivative of *R. robustus* – with an evolutionary route paralleling that of *T. infestans*. Recent studies using isoenzymes for example, indicate a virtual absence of gene flow between domestic *R. prolixus* populations in Colombia, and silvatic populations in nearby palm trees[7]. Morphometric and DNA comparisons also support the idea that domestic and silvatic populations of *R. prolixus*, although indistinguishable by classical morphology, may in fact represent different species, although the data set is still rather small to affirm this as a general rule.

The geographical distribution of *R. prolixus* is also source of some controversy. It is widespread in the llanos (plains) and central Magdalena valley of Colombia, and widely distributed in Venezuela where it seems to be increasing in abundance after widespread control interventions during the 1960s. It is not found in Panama, however, where the main vector is the related but clearly distinguishable *R. pallescens*, and yet it is common in houses in Honduras, Guatemala, Nicaragua and El Salvador. One theory to explain this discontinuous distribution, attributed to C.J. Gamboa in Venezuela, involves passive carriage of *Rhodnius* eggs and young nymphs amongst the feathers of migrating storks (*Mycteria americana*), which often nest in palm trees. But this is unconvincing because silvatic populations of *R. prolixus* have

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Table 1. Chagas disease in Mexico, Central America and the Andean Pact region

	Seroprevalence[a]	Incidence[b]	Main vectors
Mexico and Central America			
Mexico	540000	10854	Various
Belize	600	26	*Triatoma dimidiata*
Guatemala	730000	28387	*Rhodnius prolixus*
Honduras	300000	11490	*Rhodnius prolixus*
El Salvador	322000	10594	*Rhodnius prolixus*
Nicaragua	67000	2660	*Rhodnius prolixus*
Costa Rica	130000	3320	*Triatoma dimidiata*
Panama	220000	5346	*Rhodnius pallescens*
Total	**2309600**	**72677**	
Andean Pact region			
Colombia	1300000	31330	*Rhodnius prolixus*
Ecuador	450000	13365	*Triatoma dimidiata*
Venezuela	800000	22960	*Rhodnius prolixus*
Peru (north)	150000	4470	Various
(south)	490000	14602	*Triatoma infestans*
Total	**3190000**	**86237**	

[a] Seroprevalence data for Mexico are taken from Velasco Castrejón *et al.*[9], for Ecuador from Aguilar (in Ref. 6), for Colombia from F. Guhl *et al.* (unpublished), and for other countries from WHO estimates.
[b] Incidence is calculated using the model of Hayes and Schofield[10].

never been recorded from Central America. The alternative suggestion, attributed to R. Zeledón of Costa Rica, involves a possible escape of laboratory-bred bugs from a Central American laboratory in 1915. The documented spread of *R. prolixus* in Central America accords well with this idea, as do the limited genetic data so far available. The implication, of course, which is currently being tested, is that Central American *R. prolixus* represents but a limited and fairly homogenous subset of the genetic variability of the original forms collected from houses in Venezuela. As such, they could represent a feasible target for eradication in much the same way as the domestic forms of *T. infestans* in the Southern Cone region.

Control of domestic Triatominae, as illustrated by the Southern Cone experience, is a major exercise of organizational complexity, but represents few technical problems. The basic strategy involves house spraying with a modern pyrethroid such as deltamethrin, lambda-cyhalothrin or cyfluthrin, followed by long-term, community-based surveillance designed to report any residual infestations that can then be selectively retreated. The key is to achieve very wide geographical coverage in order to eliminate any possibility of reinvasion from untreated houses. In the case of *T. infestans*, we have already demonstrated that residual infestations can be distinguished from reinfestations on the basis of genetic characteristics, which is an important aid to the surveillance phase of the control programme[8]. And genetic studies already indicate that similar markers will be available to assist in controlling *Rhodnius*.

Rhodnius prolixus is certainly not the only vector of Chagas disease in Central America and Mexico (see Fig. 1), although it is generally the most significant, often building up domestic colonies of many thousands of individuals (the 'record' relates to a single house in Honduras found to contain well over 11000 bugs!). By contrast, *Triatoma dimidiata* is much more widespread, but seems to be a relatively poor colonizer of human dwellings, and is generally associated with much lower prevalence rates of *T. cruzi* infection[11]. In Mexico, there is a whole complex of species, often known as the *T. phyllosoma* group, which also seem to be widespread but relatively poor vectors. Mexico also has one autochthonous species, *T. barberi*, which seems to be a good vector and whose silvatic origins are quite unknown. A wide variety of other species have been recorded from the region, whose habits seem to be entirely silvatic.

In summary, and much to the credit of the countries concerned, the social and economic importance of Chagas disease is now being well recognized in the region, along with the technical feasibility of large-scale control interventions. The necessary control and surveillance procedures are being developed and tested in the region, and the primary vector, *R. prolixus*, may be a feasible target for local eradication. Control of other autochthonous vectors may be more difficult because of their residual foci in silvatic habitats, but it is generally agreed that community-based surveillance programmes organized as an integral part of the initial control interventions will allow selective control of autochthonous species wherever they attempt to colonize rural houses. The experience of the Southern Cone has shown that Chagas disease transmission can be halted, and it may be that similar success awaits large areas of Central America and Mexico, and possibly Andean Pact countries as well.

References

1 Kingman, S. (1991) **South America declares war on Chagas disease.** *New Sci.* (19 October), 16–17
2 Schofield, C.J. and Dias, J.C.P. (1991) **A cost-benefit analysis of Chagas disease control.** *Mem. Inst. Oswaldo Cruz* 86, 285–295
3 Del Rey, E.C., Basombrio, M.A. and Rojas, C.L. (1995) **Beneficios brutos de la prevención del mal de Chagas.** *Castañares* 3, cuad. 4 75pp
4 Urbina, J.A. *et al.* (1996) **Cure of short- and long-term experimental Chagas disease using DO870.** *Science* 273, 968–971
5 Dujardin, J.P., Schofield, C.J. and Tibayrenc, M. **Population structure of Andean *Triatoma infestans*: an isozymic study and its epidemiological relevance.** *Med. Vet. Entomol.* (in press)
6 Schofield, C.J., Dujardin, J-P. and Jurberg, J., eds (1996) *Proceedings of the International Workshop on Population Genetics and Control of Triatominae, Santo Domingo de los Colorados, Ecuador*, INDRE Mexico City
7 Lopez, G. and Moreno, J. (1995) **Genetic variability and differentiation between populations of *Rhodnius prolixus* and *R. pallescens*, vectors of Chagas disease in Colombia.** *Mem. Inst. Oswaldo Cruz* 90, 353–358
8 Dujardin, J.P., Cardozo, L. and Schofield, C.J. (1996) **Genetic analysis of *Triatoma infestans* following insecticidal control interventions in central Bolivia.** *Acta Trop.* 61, 263–266
9 Velasco Castrejón, O. *et al.* (1992) **Seroepidemiologia de la Enfermedad de Chagas en Mexico.** *Salud Publica de Mexico* 34, 186–196
10 Hayes, R.J. and Schofield, C.J. (1990) **Estimación de las tasas de incidencia de infecciones crónicas a partir de la prevalencia: la enfermedad de Chagas en America Latina.** *Boletin de la Oficina Sanitaria Panamericana* 108, 308–316
11 [illegible] *...al de la Enfermedad de Chagas en Honduras*, pp 1–7, Ministerio de Salud Publica/OMS, Tegucigalpa