

Re-infestation of Houses by *Triatoma dimidiata* after Intra-domicile Insecticide Application in the Yucatán Peninsula, Mexico

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In most countries, Chagas disease transmission control remains based on domestic insecticide application. We thus evaluated the efficacy of intra-domicile cyfluthrin spraying for the control of Triatoma dimidiata, the only Chagas disease vector in the Yucatán peninsula, Mexico, and monitored potential re-infestation every 15 days for up to 9 months. We found that there was a re-infestation of houses by adult bugs starting 4 months after insecticide application, possibly from sylvatic/peridomicile areas. This points out the need to take into account the potential dispersal of sylvatic/peridomestic adult bugs into the domiciles as well as continuity action for an effective vector control.

Key words: vector control - pyrethroides - re-colonization - peridomestic populations - sylvatic environments - Mexico

Chagas disease, or American trypanosomiasis, is caused by the protozoan parasite *Trypanosoma cruzi*, and it represents a major public health problem in Latin America, including Mexico (Dumonteil 1999). Because of difficulties associated with therapeutic treatment, and the elusive development of an effective vaccine, control of the transmission of Chagas disease remains based on vector control by insecticides (Silveira & Vinhaes 1999) and on blood bank screening (Schmuñis 1999). Vector control programs in South America have focused on the interruption of natural transmission by attacking domiciliated vector populations using pyrethroid insecticides (Silveira & Vinhaes 1999), and they have been enormously successful. The interruption of natural transmission is thus underway in the Southern Cone countries (Argentina, Brazil, Bolivia, and Chile) (WHO 1997). However, re-colonization of houses by migrating insects (from the same or other species) from sylvatic/peridomestic environments has been documented, as well as the reemergence of populations from surviving bugs (Forattini et al. 1984, Gorla 1991, Schofield 1991, Scorza et al. 1994, Gajate et al. 1996, Oliveira-Filho 1997, Dujardin et al. 1999, Almeida et al. 2000).

In the Yucatán peninsula, Mexico, the main vector of Chagas disease is *Triatoma dimidiata*. This species can be found in a variety of environments, including domestic, peridomestic and sylvatic environments (Zeledón 1981, Rodas et al. 1998). In a previous study, we documented strong seasonal variation in domiciliated and peridomestic

populations. The analysis of the population stage structure led us to suggest that flying adults (from sylvatic or peridomestic environments) were seasonally infesting houses (Dumonteil et al. 2002). An important implication of this conclusion is that control programs may have to be designed to take this particular behaviour into account. Indeed, it is not clear whether elimination of domestic populations would be sufficient to reduce house infestation by *T. dimidiata* and the risk of natural transmission of Chagas disease to humans in the region.

Initial data on the control of *T. dimidiata* in Central America suggested that domestic populations can be effectively eliminated for up to a year with a single application of pyrethroids (Rodas et al. 1998, Acevedo et al. 2000), allowing for very cost-effective control. However, no data were available in the Yucatán peninsula, where no control program has yet been established. We thus performed a pilot study to evaluate the usefulness of a vector control program based on a similar intra-domestic insecticide application on a small number of infested houses in Yucatán, Mexico.

MATERIALS AND METHODS

Study area - Field work was carried out from November 2000 to August 2001 in the state of Yucatán, located in the Southeast of Mexico, between 87-92°W and 17-22°N. We selected two villages: Eknackán and Dzidzilche, where we had been working since 1999 and had observed levels of house infestation by *T. dimidiata* of about 20 bugs/house/year (Dumonteil et al. 2002). During our previous studies in these villages, the majority of bugs were collected between April and June, and about 80% of the houses were infested. This house infestation of *T. dimidiata* is characteristic of the northern part of the Yucatán peninsula, which we defined as the region with higher risk of natural transmission in the peninsula (Dumonteil et al. 2002). There were 57 and 54 registered houses in Eknakan and Dzidzilche, respectively, with 319 and 244 inhabitants (4-6 inhabitants/domicile).

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Infestation monitoring before and after insecticide spraying - While most studies focus on various houses that are usually monitored only once or twice after 6 months or a year following insecticide application (Cecere et al. 1997, Diotaiuti et al. 1998, Acevedo et al. 2000), we decided to focus on four houses (two in each village) to be able to carry out a more frequent and detailed monitoring of re-infestation. We included representative houses with different characteristics as we had shown previously that there was no significant difference in apparent house infestation according to building materials (Dumonteil et al. 2002). Two houses were made of plastered stones (*mampostería*) with a flat cement roof, and cement floor; one house had plastered stone walls, with a galvanized tin roof and the floor was part cement and part dirt; and the fourth house had adobe walls, a thatched roof and cement floor. Doors and windows did not close effectively leaving several openings. All houses were surrounded by yards (typically 20 x 60 m) with a variety of fruit trees (banana, orange, lime, coco, mango) and free-ranging chickens and turkeys. In each village, one house was in the periphery, about 100 m from the sylvatic area, and one was more central, over 500 m away from the sylvatic area. The sylvatic area was mostly composed of bushes from abandoned areas with small patches of low forest, cultivated land (mostly henequen and corn), and a few open pastures.

House infestation was evaluated before insecticide spraying through a timed manual search for triatomines (Gürtler et al. 1999) performed by research personnel in domestic (inside houses), peridomestic (within 50 m around houses), and sylvatic habitats (more than 500 m away from the villages). Teams of two researchers performed the manual searches for 30 min in each biotope between 8:00 am and 1:00 pm. Domestic searches included walls, base of the roofs, furniture and hammocks. Peridomestic and sylvatic searches focused on animal housing (often chickens or pigs), wood piles, tree trunks, potential animal burrows or nests, piled rocks, and any other potential triatomine refuges.

Following the initial search, the interior of the four houses was sprayed with 50 mg/m² of cyfluthrin (Solfac®, Bayer) to eliminate domestic bug populations. Such a dose of this pyrethroid was found to be effective against a wide variety of triatomine species, including *T. dimidiata* (Rodas et al. 1998, Oliveira-Filho 1999, Acevedo et al. 2000). To detect re-infestation by triatomines, all houses were then carefully monitored by timed manual searches as described above, every 15 days for 9 months in all three biotopes. In addition, households were asked to collect all bugs they could find between visits to improve the sensitivity of monitoring. In addition to the manual searches, mouse traps were also used for sylvatic and peri-domestic biotopes (Magallon-Gastelum et al. 2001, Noireau et al. 2002). Seven to ten wire traps containing a single mouse each and partially covered with double-face adhesive tape were left overnight in each biotope, every 15 days, near potential animal burrows, piled wood or rocks, and other potential bug refuges. Bugs caught on the tape or around the trap were collected the next morning (Magallon-Gastelum et al. 2001, Noireau et al. 2002).

RESULTS

A total of 184 bugs was collected, most of them by manual collection by research personnel or the inhabitants of the premises (168 bugs) and only 16 bugs were collected with mouse traps. Eighty one were domestic, 86 peridomestic and 17 sylvatic. In the peridomestic, only seven bugs were collected with a total of 207 mouse traps over 29 nights (8% of peridomestic collections), and in the sylvatic area, nine bugs were collected with 226 traps over 29 nights (53% of sylvatic bug collections).

Fig. 1 shows the comparative time course of *T. dimidiata* collections in the three studied biotopes (domestic, peridomestic and sylvatic), before (first time point) and after insecticide spraying. Twenty one bugs were found in three of the four studied houses prior to insecticide application with a single manual search (Fig. 1A). Two weeks following insecticide application, three dead bugs were found in one of the sprayed houses of Eknackán, where we had been unable to find any bugs during our initial search. During the next four months, from mid-november to mid-march, we could not detect bugs inside the sprayed houses, indicating that domestic populations, if present, were reduced to below detectable levels by our monitoring strategy. On the other hand, a few bugs were sporadically collected in peridomestic and sylvatic areas (Fig. 1B and C). After the first four months, live *T. dimidiata* began to be collected inside all sprayed houses (Fig. 1A), and domestic bugs were found at each visit from the end of March until the end of June.

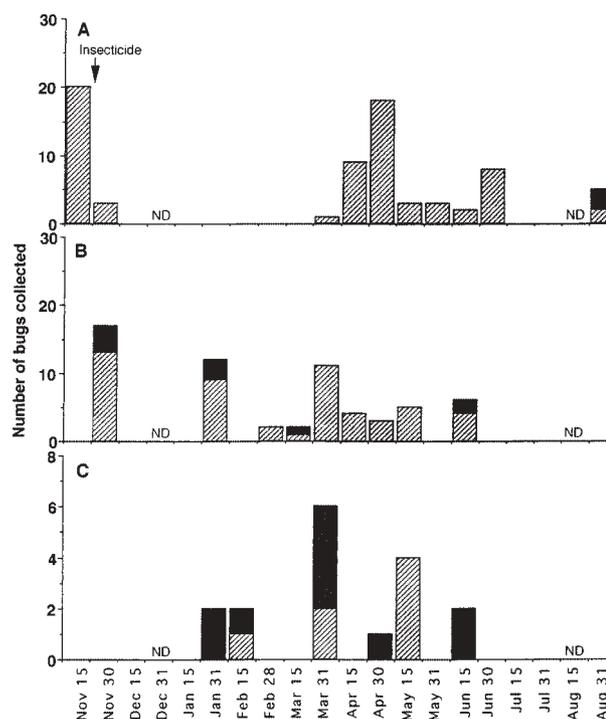


Fig. 1: time course of adult (hatched bars) and larval stages (solid bars) of *Triatoma dimidiata* collections in domestic (A), peridomestic (B), and sylvatic (C) biotopes. Data were pooled for the four sprayed houses of Eknackán and Dzidzilche. Insecticide was applied to the domestic biotope only (arrow). ND: not done

Analysis of the population stage structure of *T. dimidiata* in the distinct biotopes revealed that only adult insects were collected in the domiciles, and the first larval stages were only observed four months after the initial reappearance of adults (Fig. 1A). On the other hand, larval stages were detected throughout most of the study period in peridomestic (Fig. 1B) and sylvatic populations (Fig. 1C), suggesting that there was no marked seasonality of the reproductive cycles in these biotopes. Together, these data suggest that adult bugs migrating from nearby sites, rather than survivors of insecticide spraying, were the most likely source of new bugs in the domiciles.

DISCUSSION

Our study indicates that cyflutrin application can effectively reduce domestic populations to below detectable levels in the sprayed houses. Comparison of our data with a previous study realized during the year before insecticide spraying (Dumonteil et al. 2002) indicates that before spraying, an average of 21 bugs/house was collected in the same two villages over a one year period, while following spraying, an average of 12 bugs/house was collected over a 9 month period. As this post-spray population was exclusively composed of adults, it is more likely to be due to bugs migrating from nearby sites rather than to individuals surviving the insecticide; that is, a re-infestation process. The appearance of larval stages in the houses several months after this re-infestation by adults may indicate an attempt at colonization. This is reminiscent of our previous field observations suggesting seasonal infestation of houses by flying adults and a similar attempt at colonization that was apparently unsuccessful even in the absence of vector control. Because re-infesting bugs were removed from the domiciles at each visit, our collections may provide a rough but direct estimate of immigration rates to the domiciles. Thus, immigration of adult bugs to the domiciles during the March-June period appeared to be occurring at a rate of 2-10 bugs/house/month. This estimate is very similar to that from a population genetics study of *T. dimidiata* populations in Guatemala using RAPD markers, where the migration rate between houses from a same village was found to be of 9.7 bugs/generation (Dorn et al. 2003). A similar genetic analysis is currently underway to evaluate the respective participation of peridomestic and sylvatic populations to domestic (re)-infestation in the Yucatán.

The low efficacy of insecticide spraying for the long-term control of *T. dimidiata* in the Yucatán differs considerably from previous studies in Guatemala and Nicaragua, showing that a single insecticide application of even a small number of houses may be sufficient to control domestic *T. dimidiata* for up to a year (Rodas et al. 1998, Acevedo et al. 2000). This discrepancy may be due to the presence of other infested houses close to the sprayed ones that may have served as a source of re-infestation, and/or to a higher level of house colonization associated with lower dispersal of *T. dimidiata* in Central America compared to that of Yucatán. In fact, peridomestic and sylvatic populations are being increasingly involved in the re-infestation of domiciles following control programs (Gürtler et al. 1999), as well as in the transmission of *T.*

cruzi to humans in the absence of house colonization by triatomines (Coura et al. 1994, 1999, 2002). As suggested by a few studies on triatomine dispersal, their flying capacity may have been somewhat underestimated (Schofield et al. 1991, 1992), and need to be assessed more carefully. A possible hypothesis for the Yucatán is that seasonal changes in blood meal availability, such as from opossums, one of the main blood source for *T. dimidiata* (Quintal & Polanco 1977), may induce an increase in sylvatic/peridomestic bugs foraging activity leading to a transient infestation of the domestic areas. Analysis of feeding patterns will help testing this hypothesis.

In conclusion, the control of *T. dimidiata* domestic populations with insecticide may require continuous actions and might be optimized by taking into account *T. dimidiata* dispersal. The prevention of dispersal of sylvatic/peridomestic adult bugs into domestic areas with door/window screens or bed nets may prove to be a simple, cost-effective and sustainable complementary or alternative strategy to reduce house infestation by triatomines in this region (Kroeger et al. 1999). The usefulness of such a strategy may not be limited to the Yucatán peninsula, as the transient infestation of houses by flying sylvatic adult bugs is thought to be responsible for a significant transmission of Chagas disease in several other regions (Coura et al. 1994, 1999, 2002).

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