

Residual Effect of Lambdacyhalothrin on *Triatoma infestans*

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Insecticidal residual effect and triatomine infestation rates in houses of a community fumigated with lambdacyhalothrin (Icon) are reported. No mortality was observed in 5th-instar Triatoma infestans nymphs in 72-hr exposure test on three different surfaces, one month after fumigation for a dose of 31.5 mg ai/m². However, during post-exposure observation a mortality of 60% was recorded for those insect exposed on sprayed woodboard. The results observed with mud-containing treated walls, were markedly poorer (0% of mortality). Twelve month after spraying 40% of mortality was observed on first-instar T. infestans nymphs in 72-hr exposure test on woodborad, but lower mortality rates were observed in mud-containing materials. When the effect of deltamethrin (109 mg ai/m²) and lambdacyhalothrin (94 mg ai/m²) was compared, the former did not appear to be superior at similar loads. Both have showed a mortality rate of 30% on 5th-instar T. infestans nymphs three months post-fumigation. The dose utilized in the field fumigation was enough to get a significant ($p < 0.0001$) control of triatomine domestic infestation, since it was sufficient to keep 95% of the houses uninfested throughout 21 months following treatment, when compared with baseline situation. A remarkable knock-down effect on adult and nymphs forms of the insect and a high in situ mortality were observed as a result of its application, even at very low doses.

Key words: *Triatoma infestans* - lambdacyhalothrin - pyrethroids - insect control

South American trypanosomiasis is a disease produced by the hemoflagellate parasite *Trypanosoma cruzi*. This protozoon lives and proliferates in the gut of blood-sucking Reduviidae insects, and can be transmitted to humans producing heart and gut lesions described as Chagas' disease. It is estimated that 7.6% of the people living in Latin America is infected by *T. cruzi*, mainly in rural areas (Schofield 1985). The most frequent way of infection is via the feces of infected triatomines which defecate on the skin at the site of biting.

In Paraguay, *Triatoma infestans* was recognized as the main domestic vector for *T. cruzi* infections. Canese in 1976 established a prevalence of infestation of 11 to 60% in the Eastern region of the country (Canese & Canese 1976). An epidemiological survey conducted in a sample of

villages located in the endemic area for Chagas' disease during the period 1984-1986, revealed an infestation ranging from 0.9% to 20.5% of the houses (Arias 1990). At the same time a serological survey was conducted showing a prevalence of *T. cruzi* infection of 22% in a sample of 1601 individuals, which represented a population of 150,000 people settled in the endemic area (Arias 1990).

Fumigation has been extensively used as a means for controlling Chagas' disease vectors, and the results achieved by Brazilian programs are encouraging (Dias 1987). Vector control programs were based originally on the spraying of organochlorine insecticides, but such products were replaced by the synthetic pyrethroids in order to reduce environmental pollution. Pyrethroids like deltamethrin were shown to be effective for the control of triatomines (Marcondes & Pinto 1987, Marcondes 1989). Recently, a relatively new product of this class, lambdacyhalothrin (WHO 3021), initially directed to agricultural purposes, has been utilized in vector control. Although, has been reported its low persistence in soil when used protecting cotton plantations (Agnhotri et al. 1989), Oliveira Filho et al. accounted the control of house reinfestation by

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triatomines for more than 18 months, when lambdacyhalothrin was applied in a field test using an oil based formulation in Brazil (Oliveira Filho et al. 1988).

It is recognized that more permanent interventions such as housing improvement and education should accompany insecticide spraying for lasting effects (PAHO/WHO 1970, Schofield 1985, Briceño-Leon 1990).

Between 1989-1991 combined interventive fashions, namely, fumigation, housing improvement and fumigation plus housing improvement were performed in three rural communities of a Chagas' disease endemic area of Paraguay. In this paper we report the results of the residual effect of the insecticide and the triatomine infestation rates in the houses of a community fumigated with lambdacyhalothrin.

MATERIALS AND METHODS

Study locality - Cañada is a small community, located in the Ybytymí district, Department of Paraguari, in the Eastern Region of Paraguay. The community is located on a humid plain surrounded by smooth slopes. The mean annual temperature in this region is 21°C (38.5°C maximum in summer time) and a mean annual rainfall of 1500-1600 mm. There were 50 houses in the community, which mainly have straw roves (98%) and dirt floor (100%). The most prevalent building material found in the walls were wattle and mud (54%), woodboard (16%) and bricks without plaster (12%). The mean area of the houses was 64.3 m². The average surface of closed spaces in each house was 43.3 m², and the mean value of open spaces (corridors) was 19.3 m². Each house had three rooms as an average.

Insecticide and spraying - Lambdacyhalothrin (WHO 3021) was used in a wettable powder formulation, Icon WP10 (ICI, Brazil). The product was dissolved as directed by the manufacturers; i.e., one bag content (75 g containing 10% of active material) in 10 liter water. Insecticide application was performed with a 20-liter PIH series 8000 fumigator (JACTO, Pompeia, Brazil), endowed with hose and nozzles 80.02E, having an average delivery rate of 1010 ml/min. The spraying was done holding the nozzle about 45 cm from the surface of application and spanning a 70 to 75-cm wide area. The dose was calculated following the manufacturers directions; i.e., 30-50 mg/m². Forty-five houses were sprayed on their inner and outer walls, the lower surface of the roofs and the eaves. Permanent peri-domiciliary buildings were also sprayed. Three owners refused the fumigation and two houses were abandoned. The intervention was completed in four days and was done in summer time (December 1989-January 1990). As an average, 42.4 ml of the dilution was sprayed, corresponding to 31.5 mg of active material/m². In order to com-

pare the residual effect of two different pyrethroids, two houses from the same community, not treated previously, were sprayed separately, one with lambdacyhalothrin and one with deltamethrin. Lambdacyhalothrin (Icon WP10) was sprayed at a rate of 109 mg of active material/m², and deltamethrin (K-Othrine SC25) at a rate of 94 mg of active material/m².

Triatomine survey - Baseline evaluation of triatomid infestation of the houses was performed by trained technicians in both domestic and peridomestic environments. It was recorded the presence of either live triatomines, either adults or nymphs, fertile eggs and/or fresh feces, in order to certify active infestation. The presence of vestiges, as hatched eggs and dry feces, was also recorded. Post-fumigation survey was performed every six months during two years, by active search conducted by trained personnel.

Evaluation of the residual effects - Residual effects were evaluated one, six and twelve months after spraying by exposing ten *T. infestans* nymphs on the indoor insecticide-treated surfaces. It is carried out by holding the insects in place by using plastic cones attached to the walls with nails. After 72 hr, insects were picked, mortality rates were recorded and live insects were transferred onto filter paper and observed in the laboratory for several days in order to observe delayed effect of insecticide. The tests were performed in three houses having different wall materials, i.e. wood board, wattle with mud, and wattle with mud painted with lime (old painting).

RESULTS

The first evaluation of the residual effect of lambdacyhalothrin was performed one month after fumigation by exposing 5rd-instar *T. infestans*-nymphs during 72 hr on the three different surfaces treated. Knock-down effect was observed on all of the insects exposed to the different treated surfaces. However no dead insects were observed at the end of the exposure period. Only the ones exposed to treated wood board when they were moved onto filter paper showed a late mortality of 40 and 60%, at 5 and 7 days post-exposure, respectively. Those insects exposed to sprayed mud walls remained alive after seven days in the laboratory (Table I).

Evaluation of the residual effects was repeated six months after insecticide application at the same houses using fifth-instar *T. infestans* nymphs exposed for 72 hr. At that time, all of the insects were alive, but 60% of those placed on wood board were found detached from the sprayed surface, although just one of them showed late mortality. None of the insects placed on mud walls was died after the exposure time, and just one died in the laboratory. It is interesting to note that two of the insects exposed on wood board and two of those placed on mud

painted with lime moulted in the laboratory (Table I).

One year after fumigation of the houses, the test of the residual effect was repeated using both first- and fifth-instar *T. infestans* nymphs. In this evaluation first-instar nymphs were included in order to increase the sensibility of the assay. The insects were exposed to the three different surfaces of the same three houses during 72 hr. All of the fifth-instar nymphs placed on mud and mud plus lime surfaces survive even after the seven-day observation period carried out in the laboratory. From those insects exposed on the wood surface, just one out of ten was found dead. All of the insects exposed to mud walls remained alive after seven days in the laboratory (Table I).

TABLE I

Mortality percentage of fifth-instar *Triatoma infestans* nymphs according to wall type after fumigation with lambdacyhalothrin (ten insects/observation)

Wall type	Post-spraying observation time (months)					
	1		6		12	
	72 hr	7 days	72 hr	7 days	72 hr	7 days
Wood board	0	60	0 ^a	10	10	10
Wattle and mud	0	0	0 ^b	10	0	0
Wattle, mud and lime	0	0	0 ^c	0	0	0

^a: six bugs were found knocked down, yet they recovered in the laboratory after five days. Out of the nine survivors, two moulted in the laboratory

^b: one of the bugs was found knocked down and soon died in the laboratory

^c: two of the bugs moulted in the laboratory

In order to detect low residual effect twelve months after spraying, parallel experiments were made using first-instar nymphs. In this set of experiments a 40% mortality rate was observed on those insects placed on sprayed wood. This initial rate increased 10% more during the observation period in the laboratory. All of the insects exposed on treated mud surface were found alive, and just one of those placed on mud and lime wall was retrieved died. No cases of late mortality were observed in those insects exposed on both mud surfaces. It should be mentioned that in the consecutive observations at each house different parts of the walls were employed to expose the insects (Table II).

In order to corroborate the results of the bioassay, two neighboring control houses which had not been fumigated during the intervention period, were sprayed, one of them with lambdacyhalothrin (Icon WP10), and the other one with deltamethrin (K-Othrine 25SC). The walls of the two control houses were of the same material as the experimental ones; i.e., wattle and mud. The

TABLE II

Mortality percentage of first-instar *Triatoma infestans* nymphs according to wall type twelve months after fumigation with lambdacyhalothrin (ten insects/observation)

Wall type	Observation time			
	72 hr	4 days	5 days	7 days
Wood board	40	50	50	50
Wattle and mud	0	0	0	0
Wattle, mud and lime	10	10	10	10

house treated with lambdacyhalothrin received 145 ml of spraying solution/cm² (109 mg ai/m²), and that of K-Othrine 188 ml of spraying solution/cm² (94 mg ai/m²). The residual effects of these applications were evaluated one month after by exposing ten first-instar nymphs and ten fifth-instar nymphs on the inner walls of each house for 72 hr. The experiment carried out using the most sensitive first-instar nymphs showed mortality rate of 70% and 80% for lambdacyhalothrin and deltamethrin, respectively, after the 72-hr exposure period. Such rate increased to 100% at the 10th day of observation in the laboratory for the insects exposed to deltamethrin, but it remained invariable for those insects placed in the house treated with lambdacyhalothrin. All of the fifth-instar nymphs were found alive from both, lambdacyhalothrin and deltamethrin treated surfaces, but a permanent knock-down effect was observed on the insects exposed to both insecticides. By the fifth day of observation in the laboratory, a mortality rate of 70% was recorded for lambdacyhalothrin-exposed insects. Such rate remained invariable by day 10th. Insects exposed to deltamethrin showed 20% of delayed mortality at day fifth, that increased to 100% by day 10th.

Three months after insecticide spraying in these two control houses, evaluation of residual effects was repeated by exposure of 5th-instar *T. infestans* nymphs for 72 hr. A 30% mortality rate was observed in those insects exposed to lambdacyhalothrin after the 72-hr exposure period. At the same time, none of the insects exposed to deltamethrin appeared died, a delayed mortality of 30% was reached by day 10th.

Baseline evaluation of infestation revealed that 19 out of 45 houses (42.2%) were infested by triatomines at that moment in the domestic environment. This was evidenced by the finding live triatomines, either adults or nymphs, fertile eggs and/or fresh feces. Considering the houses were live triatomines were caught, triatomine density was 13.3% and the crowding index was 383.3. Six months following insecticide application, the

search of triatomines was repeated. Concerning domestic environment, the results were positive in 2 out of the 44 houses evaluated (one of the houses had been thrown down in the mean time). In one of the houses, an adult *T. infestans* bug was caught, and fresh insect faeces were found in another house. These results represent a 4.5% infestation rate six months after fumigation. This evaluation was repeated 12 and 21 months after fumigation and the same infestation rate (4.5%) was recorded in each survey. Infestation rates pre and post-treatment were statistically significant ($p < 0.0001$, Chi-square test, Yates corrected, Table III).

In the peridomestic environment, positive infestation was recorded in four out of 45 houses during the pre-intervention survey. Peridomestic environment remained uninfested six, 12 and 21 months after spraying (Table III).

TABLE III

Houses infested by *Triatoma infestans* pre and post fumigation with lambda-cyhalothrin in domestic and peridomestic areas (infested dwellings/examined dwellings)

Area	Observation time			
	Baseline	6 months	12 months	21 months
Domestic	19/45	2/44 ^a	2/44 ^a	2/44 ^a
Peridomestic	4/45	0/44 ^b	0/44 ^b	0/44 ^b

^a: Chi-square, Yates corrected = 15.35, $p < 0.0001$

^b: Chi-square, Yates corrected = 2.29, $p < 0.2$

DISCUSSION

The present study, initially designed as a check of insecticide application to control domestic Chagas' disease vector, provides interesting information on the residual effect of the relatively new pyrethroid lambda-cyhalothrin on *T. infestans*. Although the data reported here resulted from a small number of observations, they are of interest due to the lack of local information on the residual effect of pyrethroids for the control of triatomines.

The influence of the surface composition in the role of the persistence of the insecticide activity has been deeply studied in organochlorine insecticides (Penna 1984, 1985). Judging by our data, the absorption of insecticide by different surfaces resulted in a rapid decay of its residual effect in our biological tests, mortality was not observed in the 72-hr exposure test using fifth-instar nymphs one month post-fumigation. Delayed mortality was recorded when the insects were placed on treated wood surfaces, but if we look at the results observed with mud-containing treated

walls, they are markedly poorer. Observation of the insects in the laboratory after exposure to the insecticide was not extended beyond seven days because previous experiments had shown no change in mortality rate after this period of time.

The residual effect of lambda-cyhalothrin, in the wettable powder formulation, is related better with the nature of the treated substrate rather than with the dose. Wood board appeared to sustain the highest residual effects, when compared with mud-containing surfaces. Such observation can be explained considering the more permeable and aggressive condition - in terms of insecticide degradation - of the mud, compared with the wood board. This fact is critical considering that mud and bricks are the most popular building materials employed for housing in the endemic area for Chagas' disease in Paraguay.

Concerning the dose, although the mortality of fifth-instar nymphs in the bioassay increased with higher insecticide loads, as observed in the experiment where the effects of deltamethrin and lambda-cyhalothrin are compared when the dose of insecticide was increased from 31.5 mg ai/m² to 109.0 mg ai/m², complete mortality was not observed after the 72-hr exposure period one month after spraying, even when the most sensitive first-instar nymphs were used. These observations contrast markedly with the low infestation rates of the treated houses as determined by active search of triatomines during the post-intervention evaluations.

From the results of the comparison of the residual effect of deltamethrin and lambda-cyhalothrin, the former one did not appear to be superior to the latter at similar loads, even considering the dose employed (94 mg ai/m²), considering the mortality observed after the 72-hr exposure period. It was observed a higher delayed mortality due to deltamethrin than lambda-cyhalothrin in both first and fifth-instar nymphs when observed at one month after spraying. However, such difference disappeared in the observation carried out three months after fumigation.

Based on our experience, the dose utilized in the fumigation (31.5 mg ai/m²) of Cañada is enough to get with lambda-cyhalothrin a reasonable control of triatomine reinfestation, since it was sufficient to keep 95% of the houses uninfested throughout 21 months following treatment. It should also be mentioned the remarkable knock-down effect on adult and nymphs forms of the insect and the high *in situ* mortality observed as a result of its application, even at very low doses. Additionally, no complaints about toxic effects on both humans or domestic animals were notified by the householders of the community where lambda-cyhalothrin was sprayed.

The impact observed during almost two years in a single wide insecticide application of

lambda-cyhalothrin is significant, since it provided an effective vector control in a community located in an endemic area where infestation rate is up to 30% (Arias 1990). In such conditions, vector control should not rely on short term educative interventions directed to modify the knowledge and attitudes about Chagas' disease. Studies carried out by Gurtler et al. (1994), confirmed these results in an endemic community in Santiago del Estero, Argentina, where infestation increased markedly two years after a single application of deltamethrin. It is also important to notice, that if no more interventions are performed in sprayed communities, reinfestation will be observed after this period.

It is interesting to stress the difference in the meaning of two expressions commonly used in the field of vectors control, residual effect and lack of reinfestation. Residual effect relies on the amount of insecticide remaining on the treated surface, assessed in our case by a bioassay; the absence of reinfestation is a consequence of many different factors that involves the physical characteristics of the house, the knowledge and attitudes of the occupants toward the vector, the type of insecticide and the endurance of its effect, as well as the bio-ecological characteristics of the region and the social movement of the population.

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REFERENCES

- Agnihotri NP, Jain HK, Srivastava KP, Gajbhiye VT 1989. Persistence of lambda-cyhalothrin on cotton plant, soil and water. *Indian J Ent* 51: 325-333.
- Arias Rojas de A 1990. Epidemiología y vectores de la enfermedad de Chagas en el Paraguay, p.3-28. In JM Rosner, M Kawabata (eds) *Enfermedad de Chagas en el Paraguay*, EFACIM-JICA, Asunción.
- Briceño-Leon R 1990. *La casa enferma. Sociología de la Enfermedad de Chagas*. Fondo Editorial Acta Científica de Venezuela, Caracas, 149 pp.
- Canese A, Canese J. 1976. Encuesta sobre vectores de la enfermedad de Chagas en varias regiones del Paraguay. *Rev Parag Microbiol* 11: 35.
- Dias JCP 1987. Control of Chagas' disease in Brazil. *Parasitol Today* 3: 336-338.
- Gurtler RE, Petersen RM, Cecere MC, Schweigmann NJ, Chuit R, Gualtieri JM, Wisnivesky-Colli C 1994. Chagas disease in north-west Argentina: risk of domestic reinfestation by triatoma infestans after a single community-wide application of deltamethrin. *Trans R Soc Trop Med* 88: 27-30.
- Marcondes CB 1989. Eficiência de alfa cipermetrina e cipermetrina no controle de triatomíneos em Camalau, no sul da Paraíba (Hemiptera: Reduviidae). *Mem Inst Oswaldo Cruz* 84: 343-347.
- Marcondes CB, Pinto CT 1989. Avaliação da eficiência do deltametrin (K-Othrine 50FW), em doses baixas, no controle de triatomíneos em São Sebastião do Umbuzeiro, Paraíba. *Rev Soc Bras Med Trop* 22: 85-90.
- Olivera Filho A, Figueiredo MJ, Melo MTV, Santos CE, Silva EL, Dias JCP, Teixeira Neto I, Brasil LA, Bastos LC, Deus LF 1988. Evaluation of the pyrethroid lambda-cyhalothrin (OMS 3021) as a control agent for triatomines. 5th Meeting for Applied Research into the Control of Chagas' Disease, Araxá, Minas Gerais, Brazil, Appendix 6: Abstract A.2-21.
- PAHO/WHO 1970. Informe de un grupo de estudio sobre la enfermedad de Chagas. Washington, D.C.: WHO Tech. Rep. Ser. 195.
- Penna R, Bosworth A, Brasil IA, Marsden PD 1984. Persistência da atividade residual do BHC na superfície de diferentes materias de construção. *Rev Soc Bras Med Trop* 17: 95-99.
- Penna R, Oliveira AEX, Ferreira MFN, Johnson C, Bosworth A, Marsden P 1985. The influence of building material on the residual action of BHC. *Mem Inst Oswaldo Cruz* 80: 443-445.
- Schofield CJ 1985. Control of Chagas' disease vectors. *Br Med Bull* 41: 187-194.