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FIELD TRIAL OF PERMETHRIN FOR THE CONTROL OF *TRIATOMA INFESTANS*[1]

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Field trials for control of the Chagas' disease vector Triatoma infestans *were conducted with the insecticide permethrin. The results indicate that permethrin gives more effective and longer-lasting control than the benzene hexachloride customarily used for this purpose.*

Introduction

Control of Chagas' disease vectors in Central and South America has relied principally on repeated spraying of infested houses with benzene hexachloride (BHC) or dieldrin. Nevertheless, the continued use of these chlorinated hydrocarbon insecticides is currently under review. In Venezuela, strains of *Rhodnius prolixus* resistant to dieldrin and cross-resistant to BHC have already emerged *(1, 2)*, and several organophosphorus and carbamate insecticides are being evaluated as alternative control agents *(3, 4)*. In Argentina, ultra-low-volume application of malathion *(5)* has replaced BHC in a substantial part of the national campaign to control Chagas' disease. It thus seems inevitable that BHC will eventually be replaced as the preferred insecticide for triatomine control in Brazil as well.

Prolonged residual activity is considered an important feature of a triatomine control agent. For one thing, the bugs can remain hidden in deep wall-crevices many days before emerging to feed. Also, egg-laying sites are often virtually invulnerable to direct insecticide spraying, and eggs can normally take up to 20 days to hatch. Thus, to achieve effective population control it is desirable for the insecticide to have at least a few months of residual activity—and longer residual activity if prolonged protection against reinfestation is required.

The remarkably persistent synthetic pyrethroids *(6)*, which are very toxic to insects but may be considered safe for users and domestic animals, appear ideal candidates to employ in this particular pest control situation. This article describes the results of a preliminary field trial of one of these pyrethroids, permethrin (NRDC 143,[5] OMS 1821), for the control of *Triatoma infestans*, the primary vector species in Brazil.

Materials and Methods

The trial was conducted in a periurban district of Barreiras in Bahia State (12° 9' S, 44° 51' W) that had a history of heavy *T. infestans* infestation *(7)*. House walls in the area were made either of mud packed onto a wood latticework (48 per cent), adobe or other brick (23 per cent), or plaster (29 per cent). Tile roofing predominated, but 21 per cent of the houses involved did have palm-thatch roofs.

The insecticides used were permethrin (*cis:trans*, 1:3; 25 per cent wettable powder) obtained from the Wellcome Foundation, Ltd., and BHC wettable powder containing 30 per cent of the gamma isomer (supplied by the Superintendency of Public Health Campaigns—SUCAM—of the Brazilian Ministry of Health). The insecticides were applied in a

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water suspension at a rate of approximately 50 ml per square meter of sprayed surface. The applications were made with Hudson X-pert constant pressure pumps or Jacto PJH manual pumps fitted with Teejet 8002 or ICI polyjet nozzles.

Synergized pyrethrins were used as flushing-out agents to measure pre-treatment and post-treatment infestations. The two formulations used for this purpose were a 0.08 per cent solution of pyrethrins in kerosene (Alerta, Raimundo da Fonte, S.A.) and a mixture of tetramethrin and phenothrin (four parts tetramethrin to one part phenothrin) such that the total concentration of pyrethroids (in kerosene) was 0.125 per cent (Neopynamin/Sumithrin, Sumitomo Chemical Co., Ltd.).

The houses in the study area, which had previously been numbered and mapped, were divided as randomly as possible into different groups. Because the trial was designed to test the long-term effects of a single insecticide application, these groups were made as large as possible. Nevertheless, a considerable portion of these generally rustic and ramshackle dwellings were eventually eliminated from the trial because they had been demolished, abandoned, or extensively rebuilt.

In general, only houses that had been found infested during pre-treatment examinations were included in the trial. However, many other houses, especially ones showing signs of triatomine infestation (feces or exuviae), were also sprayed; and several such houses were included in the trial when the infestation was confirmed by collection of dead bugs two days after treatment. A few infested houses were left untreated because entry was denied, an occupant was in poor health and could not be removed, or a newborn child was present.

The actual spraying was performed on 10-13 September 1977. Before treatment, the perimeter of each house was measured and the approximate internal wall and roof surface area (a) was calculated according to the formula $a = 8\ (l + w) + l \cdot w$, where l and w are the length and width of the house (which is assumed to have walls 2 m high and one internal wall of length l and one of length w). The values obtained for a ranged from 46 m^2 to 224 m^2, the average being 123 m^2.

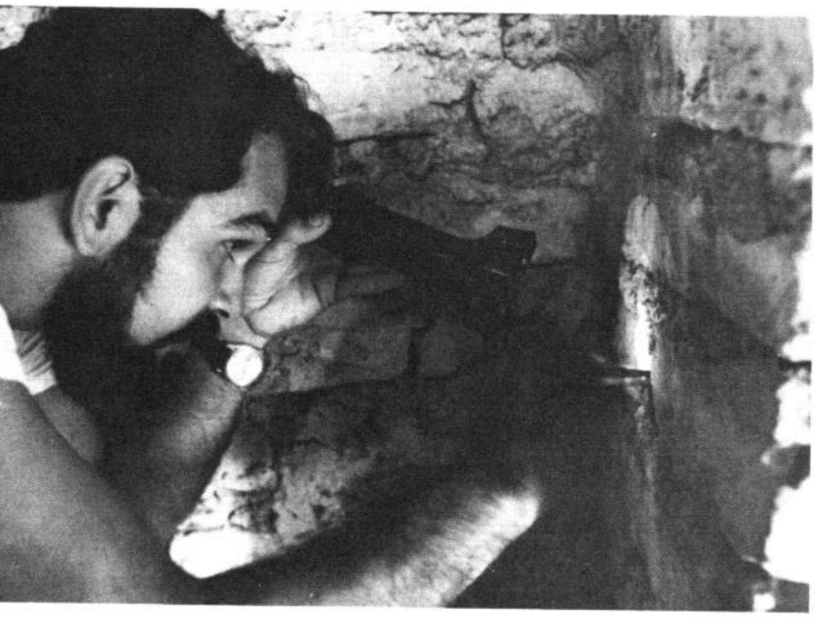
The charges of insecticide used to fill the sprayers consisted of predetermined dosages prepared for individual houses. Insecticide was then applied evenly to all internal wall surfaces and the underside of the roof. Any existing outbuildings or accumulations of material—such as chicken-houses or piles of firewood—were also sprayed. Spraymen were instructed to apply all the insecticide allotted for each house before moving on to the next.

Upon completion of spraying, the sprayman gave each homeowner a plastic bag and instructions to collect all the dead bugs that appeared. These were received by an observer two days later.

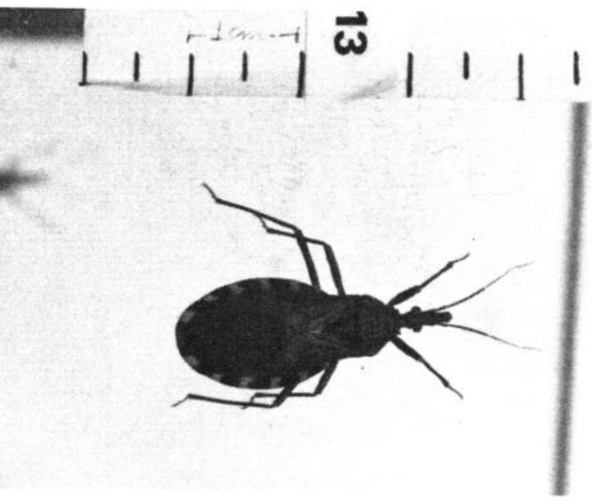
Whenever possible, an observer entered the permethrin-treated homes within 10 minutes after spraying was completed to count and record the number of bugs that had been flushed out of their hiding places by the insecticide. Then, between one and three hours later, the number of bugs "knocked down" in each house was counted and recorded.

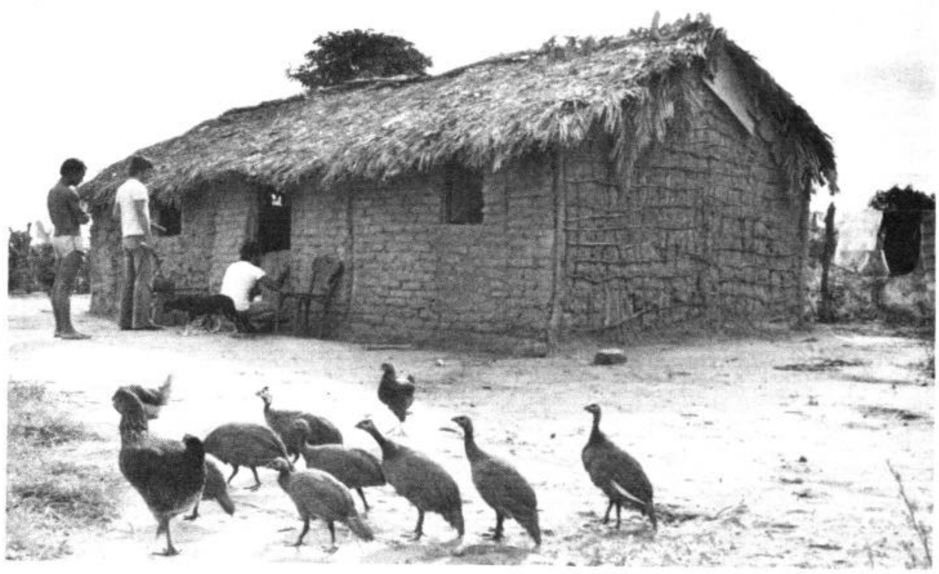
Sometime during the month before treatment, and later at 2, 7, 30, 90, 200, 300, and 520 days after treatment, each house was searched for 10 minutes by two experienced investigators equipped with flashlights and forceps. Pyrethrum or tetramethrin-based sprays were used to flush bugs out of deep cracks. The live bugs captured were separated into their instars, counted, and recorded; and the house was classified as infested or uninfested.

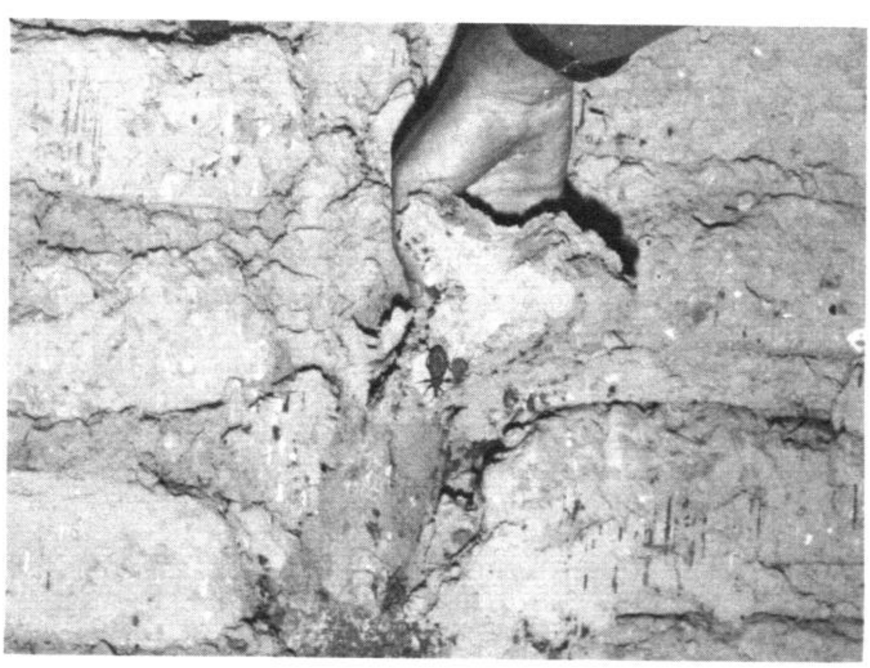
The findings obtained after two days were modified in accord with the seven-day findings. That is, if a live nymph was found on day seven in a house previously classified as "uninfested," then that house was reclassified as having been infested on day two. Similarly, the presence of third, fourth, or fifth instars on day 30 was accepted as grounds for revising the day two and seven classifications of houses previously found uninfested; and the presence of a fifth instar on day 90 was accepted as



Some field trial activities and specimens: (1) Dr. Oliveira Filho searching for triatomid bugs in crevices of a home's adobe brick wall in the area treated with permethrin. (2) A team member providing identification for a house in the suburbs of Barreiras, Bahia State, Brazil, that has been searched for *Triatoma infestans*. (3) An adult male *T. infestans,* the main vector of Chagas' disease in Brazil. (4) Nymph and adult specimens of *T. infestans* found behind a block of plaster from an adobe brick wall. Note the prominent fecal marks left by the bugs after feeding.







grounds for correcting the day 30 classification.

After each examination, the percentage of houses found bug-free and the number of bugs collected per man-hour were calculated for each group of houses—these figures being based on the number of houses examined at each reading.

Results and Discussion

The results of the trial are presented in Table 1. It is clear that the highest dosage of permethrin (2 g per square meter) provided excellent long-term control; reinfestation was not observed in any of the treated houses during the 520 days of post-treatment observation. The next-highest dosage (1 g per square meter) had a less enduring impact; that is, reinfestations were noted at 300 days post-treatment, and at 520 days over half the houses were reinfested.

At the lower level of 0.5 g per square meter, permethrin yielded early results similar to those obtained with BHC. However, the houses treated with BHC began to exhibit reinfestation after 90 days, whereas the permethrin maintained control through the first 300 days. The results obtained with the lowest dosage of permethrin (0.125 g per square meter) were unsatisfactory.

The persistence of BHC on mud surfaces, determined by bioassays with *T. infestans*, has been variously estimated at anywhere from one week *(8)* to two months *(9)*. Regrettably, it was not possible to measure the decay of residual BHC and permethrin activity directly in this trial, and so the greater persistence of permethrin had to be inferred from the results of the post-treatment examinations.

The literature contains very few reports about the length of time required for reinfestation to occur following a single application of insecticide, and most trials are concluded after only one or two post-treatment evaluations. Field trials conducted in Venezuela for *Rhodnius prolixus* control—trials performed with a product evaluation technique similar to that used in the present work—showed evident reinfestation only five months after treatment with the most efficacious insecticide tested *(3, 4)*. Although a direct comparison cannot be made, it is clear that the results obtained at 300 days after treatment with permethrin at 1 and 0.5 g per square meter—and at 520 days after application of 2 g per square meter—are quite remarkable.

The examination technique used was selected for its practical applicability to the number of houses involved in the trial. Unfortunately, with this technique it was not possible to definitely classify a house as uninfested, even using a pyrethroid spray to flush out bugs. So even though a series of consecutive negative readings by experienced field workers does give considerable assurance that a house really is bug-free, the chance of error (especially when examining houses with small bug populations such as might be found following insecticide application) is inherent in this method.

Part of this problem was eliminated by back-correcting from subsequent readings. In doing this, it was necessary to assume no migration of nymphs between houses. Only those instars whose minimum development time was longer than the interval between the two examinations in question were used to make back-corrections. These development times, from oviposition to emergence of the particular instar involved, were calculated on the basis of the work by Szumlewicz *(10)*.

Another drawback of this examination technique is that it yields no quantitative estimate of bug populations, either before or after treatment. House demolition, the only definitive method for determining the size of bug populations, was clearly impractical in this case, and methods such as release and recapture of marked bugs or sequential withdrawal sampling *(11)* were deemed too time-consuming for the field trial involved here. Consequently, our examinations were limited principally to determining whether houses were infested or not, and secondary impor-

Table 1. Results of the trial, showing the number of houses in each treatment group that were inspected before and after application of BHC or permethrin, the percentage of bug-free houses in each group, and the average number of bugs collected per man-hour in each group. The total number of houses included in each treatment group corresponds to the maximum number inspected at one time in each group.

	Permethrin												BHC (30% γ isomer, 0.5 g γ/m^2)		
	2.0 g/m^2			1.0 g/m^2			0.5 g/m^2			0 125 g/m^2					
Time of inspection	No of houses	% bug-free	Avg. bugs per man-hour	No of houses	% bug-free	Avg. bugs per man-hour	No. of houses	% bug-free	Avg bugs per man-hour	No of houses	% bug-free	Avg bugs per man-hour	No. of houses	% bug-free	Avg. bugs per man-hour
Before treatment	6	0	21.0	10	0	12.0	26	0	11.6	28	0	12.8	12	0	8.0
After treatment:															
2 days	7	29	4.7	10	30	1.8	27	33	9.2	29	24	9.7	35	43	7.8
7 days	7	29	3 0	10	40	6.3	26	54	3.8	27	26	6.4	31	45	4.0
30 days	7	100	0	10	90	0.3	26	69	1.4	29	31	7.7	32	75	3.2
90 days	6	100	0	10	100	0	25	64	3.1	29	41	10.7	31	81	1.7
200 days	7	100	0	8	100	0	20	90	0.5	26	58	13.4	27	59	3.5
300 days	7	100	0	8	87	0.4	21	95	0 6	26	62	10.8	27	74	1 7
520 days	4	100	0	8	37	6.4	15	67	10.0	20	40	18.5	18	67	18.1

tance was ascribed to the actual numbers of bugs captured at any given residence.

On the other hand, a correlation was observed between the average numbers of bugs "knocked down" to the floor by the permethrin treatment (as recorded one to three hours after treatment) and the strength of the dose applied. That is, the average numbers of dead or intoxicated bugs per house were 6.2, 8.3, 12.3, and 19.1, respectively, for the groups of houses receiving 0.125, 0.5, 1.0, and 2.0 g of permethrin per square meter.

In general a strong flushing-out effect was observed for permethrin, and many bugs appeared on the walls even before spraying was completed. However, it was not possible to make quantitatively significant observations because the size of the original bug population was not known and it proved extremely difficult to count the emerging bugs, especially smaller instars, on large wall-surface areas in poorly illuminated homes.

It has been claimed that joint application of pyrethrum and BHC improves the efficacy of the latter insecticide *(9, 12)*. Evidently the number of bugs that come into contact with the freshly deposited BHC is increased, though it remains to be proved that this significantly affects the overall performance of BHC as a control agent. In this trial, most houses in the groups treated with permethrin at 1 and 2 g per square meter—doses later yielding complete control—were still infested one week after spraying. As the flushing-out effect is only transitory, this would suggest that it is not so important as residual activity in controlling the bug population.

The permethrin formulation used remained suspended very well, whereas the BHC deposited out very rapidly. In contrast to the unpleasant skin irritation caused by BHC, the permethrin was not found to cause any adverse human reactions. Whether the prolonged and more effective control levels attainable with permethrin will offset its higher cost remains to be seen, but it seems clear that it must be considered as a candidate insecticide for control of domestic triatomine infestations.

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SUMMARY

Until now, efforts to control the vectors of Chagas' disease have relied principally upon the chlorinated insecticides BHC and dieldrin. However, there is a current trend toward replacement of these insecticides with others. This article describes the results of a field trial with one possible replacement, permethrin, a light-stable synthetic pyrethroid (NRDC 143, OMS 1821).

Groups of houses, all infested with the vector *Triatoma infestans,* were sprayed with permethrin (25 per cent wettable powder) at 0.125, 0.5, 1.0, and 2.0 grams per square meter. BHC (wettable

powder, 30 per cent gamma isomer) was also applied at 0.5 grams of gamma isomer per square meter. The amounts of insecticide to be applied were measured out for each individual house, the approximate internal surface area of each house having been estimated on the basis of a simple formula.

Shortly after completion of spraying, the flushing-out and knock-down effects of permethrin were noted. Subsequently, live *T. infestans* were collected from the treated houses at intervals of 2, 7, 30, 90, 200, 300, and 520 days after treatment. A pyrethroid-based flushing-out agent was employed during these collection surveys. The relative effect of the treatments was indicated by the percentage of houses in each group found to be bug-free at each collection period.

The highest dosage of permethrin (2 g per square meter) gave excellent prolonged control; no reinfestation was detected in any of the houses treated during the 520-day observation period. Good control was also obtained with 1 g per square meter, though reinfestation became apparent 300 days after treatment, and at 520 days over half the houses were found to be infested.

The degree of control obtained with 0.5 grams per square meter was lower, though only the collection at 520 days showed extensive reinfestation. In contrast, BHC provided only a moderate degree of control, and reinfestation was observed after 90 days. The results obtained with the lowest dose of permethrin (0.125 g per square meter) were unsatisfactory.

Overall, these findings indicate that permethrin provides more effective and longer-term control over triatomines than BHC, though whether these advantages will offset permethrin's higher cost is unknown.

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