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BIOLOGICAL ACTIVITY OF PERMETHRIN, PHENOTHRIN/ALLERTHRIN AND D-PHENOTHRIN ON *PERIPLANETA AMERICANA* AND *BLATTELLA GERMANICA* COCKROACHES
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BIOLOGICAL ACTIVITY OF PERMETHRIN, PHENOTHRIN/ALLERTHRIN AND D-PHENOTHRIN ON *PERIPLANETA AMERICANA* AND *BLATTELLA GERMANICA* COCKROACHES

N. LUKWA and V. MANOKORE

SUMMARY

The biological activity of permethrin, phenothrin/allethrin and d-phenothrin was evaluated against Periplaneta americana and Blattella germanica cockroaches. A decrease in the number of cockroaches caught after spraying the trial huts was observed. The decrease may be attributed to either the presence of trap-weary specimens or because P. americana is not fully attracted by left over food. One hundred percent knock down was achieved after 10 minutes for all insecticides. The knock down rates for d-phenothrin and permethrin were similar as compared to a combination of phenothrin/allethrin. However, all insecticides were not very effective against cockroaches because the field residual effect was from 1 day to 2 days.

INTRODUCTION

Of all the cockroach species, only a few are associated with the human home, such as Blattella germanica and Periplaneta americana. Cockroaches are mechanical carriers of diseases such as dysentery and hepatitis. In hospitals, they spread pathogens between departments, they leave unsightly droppings and unpleasant smell. Pyrethrins have been used to control cockroaches world-wide.

Scot(1) investigated the relationship between temperature and efficacy of pyrethrins on cockroaches and concluded that there was an inverse relationship. B. germanica cockroaches were tested by surface contact exposure to pyrethrins and resulted in high mortalities(2). In Zimbabwe(3) a formulation of deltamethrin/kadethrin was tested in the laboratory and this was effective against B. germanica and P. americana for 2 weeks.

All insecticides formulated as aerosols are designed in such a way that they are airborne and have no residual activity. The LC_{50} of pyrethrins on cockroaches is between 0.14ug to 0.15ug per insect(4). Therefore chances of insecticide poisoning by surface contact are rare owing to the small deposits made on the wall surfaces which are short lived. The objective of the study was to evaluate the insecticides in order for them to be registered in Zimbabwe.

MATERIALS AND METHODS

Insecticides used: Mobil consisting of 0.2 tetramethrin, 0.12 phenothrin and 0.25% allethrin was provided by Mobil Zimbabwe. Sanmex Supa Kil consisting of 0.1% tetramethrin, 0.1% permethrin and 0.5% piperonyl butoxide was provided by E.S. Marketing, Zimbabwe. Killem insect aerosol consisting of 0.2% tetramethrin, 0.5% d-phenothrin and 0.6% piperonyl butoxide was used as a standard after being obtained over a counter.

Study area: Four areas in different ecological zones were chosen for the evaluation as follows: i) Mumurwi village is situated in Musana Communal land near Mudotwe river. Malaria transmission in this area is minimal. This area has not been sprayed for 4 years. This is the main reason why a lot of flies and cockroaches have been found. The grid reference for this area is 17° 30' S X 31° 15' E and an altitude of 1 000m above sea level; (ii) Chitengu village is situated at the confluence of Nyaguwe and Mazowe rivers in Uzumba Communal land with a grid reference of 17° 15' S X 31° 4' E. The altitude is 820m above sea level. Vector mosquitoes have been found in this area with a seasonal malaria transmission pattern; (iii) Katiyo village is in Maramba Communal land at a grid reference of 17° 10' S X 31° 55' E and an altitude of 890m above sea level. Studies on mosquito behaviour have not been done in this area; (iv) Nyagande village is situated in Pfungwe Communal land along the Mazowe river. The area is characterised by mountains on three sides of the village. Inhabitants of the village engage in gold panning on the river bed during the dry season and this leaves behind puddles of water. The grid reference is 17° 5' S X 31° 50' E and an altitude of 780m above sea level.

Collection of test insects: Attractant traps consisting of 200ml wide mouthed bottles were placed in the huts used for cooking purposes in Nyagande area in order to trap cockroaches according to the method described by Masendu(3). One hundred and forty-four bottles had their inner rims coated with liquid paraffin in order to prevent the escape of catches. Left over food was used as the attractant. The traps were emptied in the morning every day for species identification.

INSECTICIDAL EFFECT

Pre-treatment assessment: Attractant traps were set up in a total of 48 randomly selected huts in Chitengu, Nyagande,

Mumurwi and Katiyo areas in order to assess the levels of cockroach infestation by counting the number of cockroaches caught each day. Left over food was placed in the bottles and used as the attractant. All caught cockroaches were released in the huts. Three huts per area were selected for each aerosol. No cockroach control was in progress before the start of the exercise.

Treatment and post treatment period: Doors were closed before the exercise began (the traps were removed). Places likely to be infested with cockroaches were sprayed and the hut vacated for 15 minutes. The spraying exercise was done once per hut in order to assess the residual effect of the aerosols. Before leaving each home, traps were reset and these were monitored over a period of 3 days.

The inhabitants were instructed to keep all dead cockroaches after sweeping the floor. Petri-dishes were provided for keeping the dead cockroaches. Mortality counts were made every 24 hours for 6 days and these were recorded on the data sheets provided. Questionnaires were administered among 24 hut occupants and 4 spray men.

Experiments on knock down effect done: Wooden cages measuring 20cm X 13cm X 4cm were constructed according to the method of Patourel (5). They were covered with mosquito netting on top, with three of the four sides nailed to wood. For the purpose of introducing insects, one side of the net was not nailed but had to be fixed with masking tape.

Thirty *P. americana* females were introduced in separate cages. The open end was closed using masking tape and the insects left to acclimatize for 10 minutes before spraying directly for 10 seconds. Subsequent experiments involved the introduction of insects in the cages without respraying. Knock down was recorded after 1 minute, 5 minutes and 10 minutes, four replicates were done for each experiment.

Residual effect of insecticides: The insecticides were sprayed on the surfaces of different cages for a period of 10 seconds. The cockroaches were exposed to the treated surfaces for 15 minutes before counting the dead ones. Field residual effect was monitored for 3 days.

RESULTS

Insecticidal effect: The following cockroaches were caught in the control huts before the spraying exercise: Chitengu 33, Nyagande 24, Mumurwi 31 and Katiyo 33. There was an average of 10 cockroaches caught per hut on a single day.

Table 1

Cockroaches encountered in the control huts over a period of 3 days (totals for 3 huts per treatment per area).

Day	Chitengu	Nyagande	Mumurwi	Katiyo
1	31	27	34	37
2	29	24	30	32
3	27	21	29	31

Cockroaches were caught in the control huts as from day 1 to 3 (Table 1). There appears to be no major difference in the number of cockroaches caught per day in each area. There was a decrease in the number of cockroaches caught after spraying the trial huts. Cockroaches were encountered at all occasions during the spraying exercise.

Table 2

Cockroaches encountered before application of insecticides (totals for 3 huts per treatment per area).

	Chitengu	Nyagande	Mumurwi	Katiyo
d - phenothrin	38	24	31	37
Permethrin	31	27	21	32
Phenothrin/allethrin	18	17	12	31

Cockroaches caught for each treatment differed in the same area, with huts which were later sprayed with phenothrin/allethrin having the least catches (Table 2). This might be explained by the least number of *B. germanica* and highest number of *P. americana* which died after insecticide application (III). Three days after spraying with permethrin, 2 cockroaches were caught in Nyagande and no catches were made in Chitengu, Mumurwi and Katiyo. No cockroaches were caught in all areas where d-phenothrin and phenothrin/allethrin had been sprayed. This might have been due to either trap-weary specimens or the repellent properties normally exhibited by insecticides and the combined effect that the majority of dead cockroaches were *P. americana*, which are not normally attracted by left over food (Table 3).

Table 3

Mortality among B. germanica/P. americana on a daily basis after spraying

	d - Phenothrin		Permethrin		Phenothrin/allethrin	
	1	2	1	2	1	2
1 day	207	701	409	759	160	1101
2 days	1	0	0	0	42	109
3 days	0	0	0	0	0	0

Key 1 *B. germanica* 2 *P. americana*

During sweeping, a total of 776 *B. germanica* and 2 561 *P. americana* were collected from 12 huts per treatment one day after the application of the 3 insecticides. Mortalities tailed off on the first day for d-phe~othrin and permethrin as compared to a phenothrin/allethrin formulation (2n day). One hundred and fifty - one cockroaches died on the second day due to phenothrin/allethrin application, 1 cockroach died due to d-phenothrin application and no dead cockroach was collected in huts where permethrin was sprayed. No dead cockroach was collected in all the 12 control huts.

For any of the insecticides, P. americana out numbered B. germanica. The use of left over food as an attractant for cockroaches is only good for sampling B. germanica rather than P. americana because this resulted in underestimation of the available cockroaches (Table II). The high presence of P. americana in these kitchens is not surprising since kitchens were used as bedrooms.

The questionnaire revealed that 48 participants were aware of the cockroach problem in their quarters. After application of insecticides, 36 participants commended on the effectiveness of the insecticides on cockroaches. Only

1 person mentioned sneezing as a result of d-phenothrin application, 3 mentioned sneezing and coughing as a result of permethrin application. This agrees with observations of the spray men who indicated sneezing and coughing during application of both a insecticides but the side effects were short lived.

Knock down tests

Table IV

Knock down effects of d-phenothrin, permethrin and phenothrin/allethrin on P. americana

Minutes	d-Phenothrin	Permethrin	Phenothrin/allethrin	Control
	%	%	%	%
1	23	20	30	0
5	77	73	57	0
10	100	100	100	0

There was a knock down of 23% after 1 minute due to d-phenothrin, 20% due to permethrin and 30% due to phenothrin/allethrin. One hundred percent knock down was achieved at a period of 10 minutes (Table 4). No immediate knock down was observed and there was no knock down on the controls.

Residual effect

Table V

Residual effect of d-phenothrin, permethrin and phenothrin/allethrin on P. americana over a 3 day period (% mortalities)

Day	d-Phenothrin	Permethrin	Phenothrin/allethrin	Control
	%	%	%	%
1	100	100	100	0
2	0	0	35	0
3	0	0	0	0

There was a 100% mortality for all insecticides when the cockroaches were exposed to the treated surface one day after treatment (Table 5). The formulations of permethrin and d-phenothrin had a residual effect of 1 day as compared to a phenothrin/allethrin combination (2 days).

DISCUSSIONS

Cockroaches were caught every day in 12 control huts during the spraying exercise (Table 1). However, there was a decrease in the number of cockroaches caught over a period of 3 days after spraying the trial huts. The decrease of catches in the control huts may be attributed to either the presence of trap weary specimens or the observed fact that *P. americana* is not fully attracted by left over food. There is also a possibility of immigration and emigration of cockroaches in between sprayed and unsprayed huts.

The insecticidal effect of all insecticides is demonstrated by the mortalities observed after spraying (Table 3) and the delayed knock down rates of 10 minutes (Table 4). One hundred percent knock down was achieved after 10 minutes for both insecticides and this has implications on the efficacy of the insecticides. The cockroaches were not dying fast enough so that they can be collected indoors and the mortalities observed might be lower than the expected because of the repellency effect associated with pyrethroids. The knock down rates of d-phenothrin and permethrin were similar as compared to a combination of phenothrin/allethrin (Table 4).

The sampling method used for catching cockroaches appears to be selective for *B. germanica* and therefore not reflecting the true population densities in the study areas. However, all insecticides were not very effective against cockroaches because the field residual effect was 1 day for d-phenothrin and permethrin and 2 days for a combination of phenothrin/allethrin. This same trend is confirmed by the laboratory residual effect of the same order (Table 4). The residual activity is not long enough for crawling insects if compared to a deltamethrin/kadethrin(3) formulation which had a field residual activity of 4 days and a laboratory residual activity of 2 weeks.

The questionnaire revealed that all participants were aware of the cockroach problem in their quarters and they all commended on the effectiveness of the insecticides on cockroaches. Minor side effects such as sneezing and coughing were reported for d-phenothrin and permethrin, but they were short lived.

In conclusion, both insecticides are not good for routine cockroach control programmes due to their non-residual activity and a delayed knock down rate.

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REFERENCES

1. Scot J.G. Effect of temperature on the toxicity of S-bioallethrin and cypermethrin to susceptible and kdr - resistant strains of *B. germanica*. *Bull. Ent. Res.* 1987; 77:431-435.
2. Scot J.G. and Matsumura F. Evidence for 2 types of toxic actions of pyrethroids on susceptible and DDT resistant *B. germanica* cockroaches. *Pestic. Biochem. Physiol.* 1983; 19:141 - 150.
3. Masendu H.T., Lukwa N., Chidende M. and Murahwa A.C. The effect of Killem knock down, deltamethrin/kadethrin on the German and American cockroaches *B. germanica* and *P. americana* (Unpublished).
4. Wadleigh R.W, Koehler P.G, Preisler H.k. Patterson R.S and Robertson J.L. Effect of temperature on toxicities of ten pyrethroids to german cockroach dictoptera: Blattidae. *J. Econ. Entomol.* 1991; 84:1433-1436.
5. Le Patourel G.N.J. and Zhou J.J. Action of amorphous silica dusts on the German cockroach *B. germanica* (L) *Bull. ent. Res.*1990; 80:11-17.