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Lack of insecticidal effect of mosquito coils containing either metofluthrin or esbiothrin on *Anopheles gambiae sensu lato* mosquitoes

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Abstract. Use of mosquito coils for personal protection against malaria and mosquito nuisance is advocated under mosquito and malaria control programmes. We performed field studies of mosquito coils containing either metofluthrin or esbiothrin in experimental huts situated in Kamhororo village, Gokwe district, Zimbabwe. All tests were performed on 3-5 day old reared female *Anopheles gambiae sensu lato* mosquitoes. The burning times were 9hr 20min for mosquito coils containing metofluthrin and 8 hr for those containing esbiothrin and the results were significantly different (p = <0.001). The mean knock down rate for mosquito coils containing metofluthrin was 90% and that for esbiothrin was 73.3% and the results were significantly different (p = 0.00). Mosquito coils containing metofluthrin had a mean repellence of 92.7% as compared to 85.4% for esbiothrin and the results were not significantly different (p=0.27). The protection time as required by EPA (1999) was 6hr for mosquito coils containing metofluthrin and 5 hr for those containing esbiothrin. The mean insecticidal effect of mosquito coils containing metofluthrin was 84% as compared to 83% for those containing esbiothrin and the results were not significantly different (p = 0.56). Both mosquito formulations could not be classified as having insecticidal effect since none of them met the 95% mortality rate criteria.

INTRODUCTION

Malaria, a mosquito-borne disease, is a serious health problem in Zimbabwe where more than 6 million people are at risk (Taylor & Mutambu, 1986). The National Malaria Control Programme co-ordinates all malaria control activities including indoor residual house spraying, mosquito larviciding and use of insecticide treated mosquito nets. The use of personal protection methods involving aerosols, mosquito repellents and coils is advocated for at national level (Murahwa *et al.*, 1994; Lukwa *et al.*, 1999). In Tanzania and Zaire, coils are attractive alternatives to insecticide house spraying because of their low cost (Coene *et al.*, 1989; Hudson & Esozed, 1971).

The use of mosquito coils is widespread as evidenced by studies conducted in Mali (Rhee *et al.*, 2005), Burkina Faso (Samuelsen *et al.*, 2004) and Tanzania (Edson & Kayombo, 2007). Mosquito coils are prescribed for travellers as a means of preventing mosquito nuisance (Lawrance & Croft 2004). Vijay- Kumar & Ramaiah, (2008) documented that the use of personal protection measures against mosquitoes (including mosquito coils) lowered the prevalence of *Wuchereria bancrofti* microfilaraemia in India. Mosquito coils containing pyrethrins provided protection against mosquitoes in laboratory experiments (Birley *et al.*, 1987; Curtis, 1992). In Zaire, mosquito coils containing DDT reduced mosquito biting by 30% (Coene *et al.*, 1989). Several authors have evaluated mosquito coils and protection times of less than 8 hr were reported (Curtis, 1992; Hudson & Esozed 1971). Mosquito coils

containing pyrethrins had a KT_{90} (time taken to knock down 90% of the mosquitoes) of 60min in Tanzania (Hudson & Esozed 1971). Ramesh & Vijayalakshmi (2001) studied the distribution of smoke of mosquito coils containing allethrin and found out that the insecticide residues could only be detected up to 6hr. In Zimbabwe, Murahwa *et al.* (1994) showed that coils caused a 100% mortality rate in *Anopheles gambiae sensu lato* mosquitoes after 1 hour exposure. The KT_{50} for mosquito coils containing pyrethrins was between 15 to 20min and the KT_{90} was between 40 and 50min (Liu *et al.*, 1987; Murahwa *et al.*, 1994). Liu *et al.* (1987) observed that mosquito coils containing pyrethrins have a very low chronic toxicity for mammals, thus making them safe for use in homes.

We evaluated the efficacy of mosquito coils containing either metofluthrin or esbiothrin as active ingredients.

MATERIALS AND METHODS

Study area

The studies were conducted in round experimental huts constructed in Kamhororo village, Gokwe. The huts were built with bricks and cement, all inside walls were plastered with mud (for the purposes of easy re-plastering whenever new tests are conducted) and the roofs were grass thatched (for easy removal when new tests are to be conducted). Each hut has 2 triangular window 'openings' (for placing window traps). All huts were surrounded by a 'collar' (containing water in order to prevent ants from entering). Mosquito coils containing either metofluthrin or esbiothrin were evaluated.

Mosquito collection

Third instar larvae of *An. gambiae s.l.* mosquitoes were collected from Kamhororo River and reared to adult stage in the field insectary. Only 3-5 day old female mosquitoes were used after being starved for 4hr.

Burning time

All mosquito coils were lit at 7am and the time taken for them to finish smouldering was recorded. Observations were made every 10 min. Five replicates for each coil were conducted.

Knock down rates

Knock down rate was measured by placing 20 female *An. gambiae s.l* mosquitoes in each paper cup. Five replicates were done for each mosquito coil. The number of mosquitoes knocked down was recorded every 10min for 2hr. The EPA (1999) (Environmental Protection Agency) criteria for a minimum of 95% knock down was used.

Repellence time

Six volunteers under prophylaxis sat in 3 different experimental huts. Esbiothrin containing mosquito coils were smouldered in one hut, metofluthrin containing mosquito coils were used in another hut and the last hut was used as a control. The mosquito coils were lit and the subjects caught mosquitoes as they came to bite them during the night (from 6 pm to 5 am). Each volunteer was in the experimental hut for 6hrs before another one took over. The volunteers rotated every 3rd day (one smoke free day was left in between experiments). A total of 500 female *An. gambiae s.l.* mosquitoes were released per day per replicate for each of the treatments. Mosquitoes were sorted out as the number of catches per hour. The EPA (1999) criteria was used (95% mosquito repellence is required). Percent repellence was calculated according to Mehr *et al.* (1985) as follows:

$$\frac{Mc-Mt*100}{Mc}$$

Where Mc is number of mosquitoes caught on the control volunteers, Mt number of mosquitoes on the treated volunteers.

Protection time

The experiments were carried as in the determination of repellence time, but time for first mosquito bite was noted as outlined by EPA (1999).

Insecticidal effect
The mosquitoes used for the knock down experiment were kept for 24hr and the mortality rate was scored. The criteria of EPA (1999) for 95% mortality as a minimum was used.

Data analysis
Data was analysed using Student's independent T test.

RESULTS

Burning time
The complete burning time for mosquito coils containing metofluthrin was 9hr 20min and that of mosquito coils containing esbiothrin was 8hr. Mosquito coils containing metofluthrin had a longer burning time than those containing esbiothrin and the results were significantly different at 95% confidence limit (p<= 0.00).

Knock down rates
The knock down rate for metofluthrin was between 70-100% and that for esbiothrin was 50-100% (Table 1). The mean knock down rate was 90% for metofluthrin and 73.3% for esbiothrin and the results were significantly different (p=0.00). The knock down time that met the EPA (1999) requirement was 40min for metofluthrin and 60min for esbiothrin.

Repellence time
Percent repellence by mosquito coils containing metofluthrin ranged from 50-100%, with 5hr meeting the EPA (1999) criteria (Table 2). On the other hand, repellence by mosquito coils containing esbiothrin ranged from 14.8-100%, with 4 hr meeting the EPA (1999) criteria. Mean repellence by mosquito coils containing metofluthrin (92.7%) was higher than that of esbiothrin (85.4%) although the results were not significantly different (p=0.27).

Protection time
The protection time as required by EPA (1999) was 6hr for metofluthrin and 5hr for esbiothrin.

Table 1: Knock down rates of *An. gambiae s.l.* mosquitoes after exposure to mosquito coils

Minutes post burning (n=100)	Metofluthrin (n=100)	Esbiothrin (n=100)
10	70.0%	50.0%
20	80.0%	60.0%
30	90.0%	80.0%
40	100.0%	70.0%
50	100.0%	80.0%
60	100.0%	100.0%
Mean	90.0%	73.3%

Table 2: Mosquito repellence of mosquito coils (absolute numbers of mosquito landings; percent repellence in brackets)

Hours post treatment	Metofluthrin (n=1500)	Esbiothrin (n=1500)	Control (n=1500)
0	0 (100%)	0 (100%)	110 (0%)
1	0 (100%)	0 (100%)	155 (0%)
2	0 (100%)	0 (100%)	135 (0%)
3	0 (100%)	0 (100%)	170 (0%)
4	0 (100%)	0 (100%)	110 (0%)
5	0 (100%)	5 (94.4%)	90 (0%)
6	5 (93.8%)	10 (87.5%)	80 (0%)
7	25 (87.5%)	40 (33.3%)	60 (0%)
8	15 (66.7%)	35 (22.2%)	45 (0%)
9	35 (50%)	60 (14.3%)	70 (0%)
Mean inhibition	7.5 (92.7%)	15 (85.4%)	102.5 (0%)

Insecticidal effect

The mortality rates due to metofluthrin ranged from 80-90% (mean 84%) and those due to esbiothrin ranged from 60-90% (mean 83%). The mean mortality rate of *An. gambiae s.l* mosquitoes due to metofluthrin was higher than that of esbiothrin although the results were not significantly different (95% confidence limit, p=0.57). There were no mortalities in the control. Both formulations could not be classified as having insecticidal effect since none of them met the 95% mortality rate criteria (EPA, 1999).

DISCUSSION

The use of mosquito coils has become important in most malaria control programmes because this method is cheap and affordable as compared to other anti-mosquito measures (Hudson & Esozed, 1971; Coene *et al.*, 1989; Murahwa *et al.*, 1994; Lukwa *et al.*, 1999). The rate at which mosquitoes are knocked down is very important in mosquito and malaria control programmes because this aspect renders them helpless until they are picked up by predators. The knock down rate of 95% required by EPA (1999) appears to be very high although it ensures that most mosquitoes are prevented from landing on a human host as long as this is fast enough before mosquitoes alight on a human being.

Our results show that mosquito coils containing metofluthrin had a fast knockdown rate than those containing esbiothrin although this rate is not fast enough to prevent disease transmission despite the fact that coils are advocated for travellers as a means for preventing malaria transmission (Lawrance & Croft, 2004). Vijay- Kumar & Ramaiah (2008) mentioned that mosquito coils lowered the prevalence of *W. bancrofti* in India but their results fail to demonstrate the direct effect of coils on disease reduction.

Our results on mosquito coils containing metofluthrin appear to be better than observations of Murahwa *et al.* (1994) although the efficacy of mosquito coils containing esbiothrin agrees with observations of the above authors. The slow knock down aspect appears to be beneficial in preventing mosquito nuisance. Observations of Hudson & Esozed (1971) on the knock down rate of mosquito coils after 60min fell well below the required standard set by EPA (1999) and our results appear to be better than theirs.

Most malaria control programmes require that mosquito coils should have a burning time of 8hr and our observations show that both mosquito coils have burning times of at least 8hr. The results appear to be better than those documented by Curtis (1992), Murahwa *et al.* (1994) and Lawrance & Croft (2004).

Inhibition of biting through mosquito repellence is another measure that is important in prevention of disease transmission. Our results suggest that both mosquito coils cannot offer full repellence of 95% for up to 8hr. However, the observed low repellence period is better than observations of Liu *et al.* (1987); Birley *et al.* (1987) and Rhee *et al.* (2005). These results suggest that mosquito coils should be used to supplement other mosquito control measures but cannot be used on their own as a sole method. Protection times until the first mosquito bite are about 6hr, suggesting that people using mosquito coils are assured of this protection. Our results agree with observations of Ramesh & Vijayalakshmi (2001) who documented that allethrin residues could only be detected up to 6hr in a room where mosquito coils were used. On the other hand, the insecticidal effect appears not to be very pronounced for both mosquito coils and falls short of the EPA (1999) requirement.

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