EFFICACY OF PERMETHRIN- AND CYPHENOTHRIN-IMPREGNATED NETTINGS AGAINST *CULEX PIPIENS PALLENS*

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ABSTRACT. Laboratory tests were conducted to determine the effect of different bed net materials, impregnated with permethrin or cyphenothrin, on *Culex* mosquitoes. Polyethylene, polyester and vinylon nettings were more efficacious than cotton or nylon.

Research on mosquito bed nets impregnated with an insecticide, as a means of self-protection from bites of mosquitoes has been reported. Hossain and Curtis (1989) compared the efficacy of permethrin treated nylon and cotton nettings against *Anopheles gambiae* Giles and *Aedes aegypti* (Linn.) in the laboratory. They observed that 2.5 g/m^2 of permethrin on nylon and 5.0 g/m^2 on cotton was required to prevent mosquitoes from biting a human arm. Lines et al. (1987) also examined the efficacy of permethrin-impregnated nylon and cotton nettings, in a window trap in an experimental hut in Tanzania, to determine the effect of the treated netting on feeding and survival of *An. gambiae* and *An. funestus* Giles. Their results indicated that cotton netting was not as effective as nylon netting. The important consideration for bed nets impregnated with insecticides is the makeup of their woven materials. We investigated the effect of permethrin- and cyphenothrin-impregnated on various netting materials on *Culex* mosquitoes. The impregnated netting was chemically analyzed to determine the amount of active ingredient on the netting and its biological effect on the mosquitoes.

Permethrin (3-(phenoxyphenol) methyl (1RS)-cis,trans-3-(2-2 dichloroethenyl)-2,2-dimethyl cyclopropanecarboxylate, cis/trans ratio 44/56, purity 95.6%) and cyphenothrin ((RS)-δ-cyano-3-phenoxybenzyl (1R)-cis, trans-chrysanthemate, purity 98.5%, Sumitomo Chemical Co., Ltd., Osaka) were formulated into emulsifiable concentrates with an emulsifier (Sorpol SM 200, Toho Chemical, Tokyo) and a xylene solvent, 10:10:80 w/w. Nettings made of cotton, polyethylene, polyester, nylon and a mixture of cotton and synthetic fiber (Vinylon, Kurare Co. Ltd., Tokyo) were used and their characteristics are shown in Table 1. Pieces of netting, 10 × 10 cm were immersed in a water diluted emulsifiable concentrate of 0.25, 0.5 and 1.0% for 5 min and dried at room temperature for 24 hours. In the case of the cotton netting, 0.125 and 0.25% concentrations were employed, as the amount of diluted solution absorbed was larger than that of other nettings.

For chemical analysis, a 5 × 5 cm piece of the netting was used. This was extracted with 20 ml of acetone solution containing an appropriate amount of diphenyl phtalate as an internal standard of permethrin and cyphenothrin. The extract was shaken for 10 min. The quantity of active ingredient was determined by gas chromatography using a Simadzu GC-7A apparatus equipped with a flame ion detector, column of 5% SE-30 on uniport HP (100-200 mesh) 1.1 m long, temperature of injection port at 280°C and oven at 240°C, nitrogen carrier gas at 50 ml/min flow, air flame at 0.6 kg/m^2 and hydrogen at 0.8 kg/m^2. The analyses were replicated 2 times.

Bioassays were performed as follows: the treated netting was fastened to a plywood panel with drawing pins. A plastic petri dish (0.7 cm deep × 3 cm diam) with a 1 cm center hole, was placed upside down on the netting. Ten 3-4 day unfed adult female *Cx. pipiens pallens* Coq. were introduced into the petri dish through the center hole and allowed to contact the netting for 20 minutes. Following exposure, the mosquitoes were transferred to a polyethylene cup and were provided with a cotton plug soaked in a 5% sugar solution. Mortality was observed after 24 hours. The experiment was replicated 3 times.

Table 2 shows the results of the chemical analysis of the treated nettings. Since the mesh size and thickness of the threads were quite different, the amount of active ingredient was expressed as ppm to the weight of the netting, instead of mg/m^2. With the exception of cotton

Table 1. Characteristics of various nettings.

Material	Mesh size**	Thickness of thread (mm)	Weight (g/m^2)
Cotton	Irregular	0.16	35.0
Polyethylene	16	0.36	133.2
Polyester	90	0.08	27.0
Nylon	14	0.26	50.7
Vinylon*	22	0.24	37.8

* A mixture of cotton and synthetic fiber.
** Threads per inch.

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Table 2. Absorption of permethrin and cyphenothrin onto various nettings.

Material	Concentration of treatment 0.25%	0.5%	1.0%
Cyphenothrin			
Cotton*	8,237 ppm	11,597 ppm	— ppm
Polyethylene	497	1,288	2,843
Polyester	1,802	3,771	5,647
Nylon	2,678	4,969	10,841
Vinylon	2,468	5,214	11,444
Permethrin			
Cotton*	5,759 ppm	20,742 ppm	— ppm
Polyethylene	1,240	1,456	3,817
Polyester	3,192	4,547	9,202
Nylon	2,496	7,463	9,581
Vinylon	3,579	8,541	9,358

* The concentrations treated were 50% of indicated values.

Table 3. Efficacy of permethrin and cyphenothrin on various nettings against *Culex pipiens pallens.*

Material	Concentration of treatment 0.25%	0.5%	1.0%
Cyphenothrin			
Cotton*	73**	43	—
Polyethylene	100	100	100
Polyester	100	100	100
Nylon	65	90	100
Vinylon	100	100	100
Permethrin			
Cotton*	28	43	—
Polyethylene	100	100	100
Polyester	100	100	100
Nylon	32	48	75
Vinylon	100	100	100

* The concentrations treated were 50% of indicated values.

** Percent mortality, based upon the average of 3 replicates. Cotton netting was used as untreated netting and 0% mortality was obtained.

netting, the amount of cyphenothrin absorbed on the threads generally depended on the concentration. Permethrin was not as much affected by concentration. Cotton netting absorbed the largest amount and polyethylene netting the smallest amount of insecticides. There were only small differences in the amount absorbed by the polyester, nylon and vinylon nettings, though the amount of cyphenothrin absorbed by the polyester netting was slightly lower than that of nylon and vinylon nettings.

Table 3 shows the efficacy of permethrin and cyphenothrin at various concentrations on various types of nettings against *Cx. pipiens pallens.* Although cotton netting absorbed the largest amount of both insecticides, its efficacy was less than that of polyethylene, which absorbed the least amount. The efficacy of each insecticide on nylon was inferior to that on polyethylene, even though nylon netting absorbed a larger amount of insecticide than did the polyethylene. These results suggest that polyethylene as a bed net material can be expected to be more efficacious at a low concentration.

Hossain and Curtis (1989) and Lines et al. (1987) both reported that permethrin-impregnated nylon nets were more effective than cotton-impregnated nets against mosquitoes. The comparative efficacy of nylon treated netting to that of cotton in this study reconfirms their observations. Rozendaal (1989) discussed the influence that the bed net fiber material had on their biological efficacy. He concluded that insecticides are less available to the insects on cotton thread than on synthetic fiber because of the apparently greater and deeper absorption of the cotton fibers. However, Snow et al. (1987) pointed out that insecticides on netting are concentrated on a far smaller area of fiber than on sheet nets and can be expected to be more effective. Additional studies should be carried out comparing netting of the same size and thread thickness.

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