SCIENTIFIC NOTE

Evaluation of Electronic Mosquito-Repelling Devices Using *Aedes albopictus* (Skuse) (Diptera: Culicidae)

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Avaliação de Aparelhos Eletrônicos Repelentes de Mosquitos Usando-se *Aedes albopictus* (Skuse) (Diptera: Culicidae)

RESUMO - Os aparelhos repelentes de mosquitos Anti-Pic®, Mosquito Repeller® DX-600 e Bye-Bye Mosquito® foram avaliados em caixas de experimentação expondo-se a mão humana a adultos de *Aedes albopictus* (Skuse). Foram realizados dois conjuntos de experimentos baseados em exposições por 15 min. No primeiro, ambas mãos foram introduzidas na caixa, estando uma delas com o aparelho ligado. No segundo foi introduzida uma mão de cada vez, segurando o aparelho, ligado ou não. Os aparelhos falharam em mostrar eficiência em ambas as avaliações. Uma aparente proteção de 30,3% pelo Anti-Pic® no primeiro conjunto de experimentos não foi confirmada no conjunto seguinte. Discute-se o valor desse recurso na prevenção da dengue.

PALAVRAS-CHAVE: Insecta, repelente, mosquito, ultra-som.

ABSTRACT - The mosquito-repelling devices Anti-Pic®, Mosquito Repeller® DX-600 and Bye-Bye Mosquito® were evaluated in boxes for experimentation by exposing human hands to *Aedes albopictus* (Skuse) adults. Two sets of tests were performed based on 15 min. expositions. In the first set both hands were introduced in the box, one of them holding the device on. In the second set only one hand was introduced each time, holdind the device on or off. The devices failed to show efficiency in both evaluations. A seemingly 30.3% repellency due to Anti-Pic® in the first set of experiments was not confirmed in the second set. It was discussed the value of such devices for dengue prevention.

KEY WORD: Insecta, repellent, mosquito, ultra-sound.

The recent increase in dengue epidemics all around the world and the real risk of resurgence of urban yellow fever has directed public concern on how to avoid *Aedes aegypti* (L.) and *Aedes albopictus* (Skuse) bites. The avoidance of mosquito bites consequently turns to the obvious- personal protection and how to obtain the perfect repellent. In a recent review (a clinician's guide) on the subject the dermatologist Mark S. Fradin (1998) stated that three approaches are not effective against mosquitoes, outdoor bug 'zappers', bat houses and ultrasonic devices.

According to Curtis (1986) the makers of electronic mosquito-repellers falsely advertise that the male sound imitated by their devices may create a sound field intolerable to females. In 1998 the radio program 'Clip Informática' (radio USP-FM, 93.7 MHz) in São Paulo, Brazil announced that an extra benefit was going to be broadcast during the regular programming, the inaudible sound of a male mosquito, an anti-mosquito sound. Almost the same was reported the previous year in a Discovery Channel TV' program. The Compiège local FM radio in north France broadcaster an ultra-sonic signal during regular programming to repel bugs and more particularly mosquitoes. Listeners interviewed during the broadcasts expressed split opinions concerning the efficiency of the process.

Foster & Lutes (1985) mention another premise used in the argument of electronic mosquito-repellent makers: mosquitoes like many other insects avoid bat ultrasonic sound that the devices imitate. Such an explanation was proposed by Costello & Brust (1976), discussed by Belton (1981), and was recently used in a popular scientific magazine in Brazil (Superinteressante 14/nº05, May, 2000) to explain why a CD mimicking bat ultrasound was 80% efficient in repelling *Ae. aegypti* females in preliminary tests.

A third and bizarre explanation was given early in the 1970s in an article entitled 'Build the bug-shoo'. According to this, mosquito females are repelled by their own sound,

around 2,000 Hz, produced by their wing beat to attract males (Belton 1981).

Here we evaluate the repellent properties of three electronic anti-mosquito devices widely available in Brazil. Some characteristics of the devices are presented in Table 1. Frequencies, sound level at two distances and the peak of the harmonics were obtained with a Brüel & Saer Model 2232 decibelimeter and with a Uniscan II digital sonograph.

Table 1. Characteristics of the three evaluated electronic anti-mosquito devices. Anti-Pic® (A-Pic) Mosquito Repeller® DX-600 (M-Re) and Bye-Bye Mosquito® (BB-M)

Device brand	Size (cm)	Range (m)[1]	Battery required	Origin	Frequency (kHz)		Sound level (dB) distance		Harmonic peak (kHz)	Cost US$
					Funda-mental	Peak	1 cm	50 cm		
A-Pic	7x6x2	6	2 AA 3v	Brazil	5.1	5.2	51.7	40.0	3.4	5
M-Re	7x3x2	4 to 5	1 AA 1.5v	Taiwan	6.0	6.1	55.0	40.2	12.3	10
BB-M (1)[2]					5.4	5.4	58.5	34.5	10.8	6
(5)	5x3x1.5	3 to 5	1 AA 1.5v	Taiwan	6.5	6.5	59.0	36.4	19.2	
(10)					8.8	8.8	58.9	36.4	17.6	

[1]Claimed by the maker.
[2]Position of the 1-10 regulating switch.

Two sets of tests were performed by exposing hands of subjects to at least 50 *A. albopictus* females in screened experimental cages (90 x 60 x 75 cm) under controlled laboratory conditions of 25±2ºC and 75±5% RH. The mosquito colony was established from field collected insects from Campinas and Bragança Paulista between 1992 and 1997. Adults were daily fed on with a 10% honey solution and weekly offered 7-day-old baby rats for blood intake. Mosquitoes were deprived from blood meals for at least two days before each experiment.

In the first set of experiments, both hands were simultaneously introduced into the experimental cage for 15 min. One hand holding a turned-on device (experimental) was held approximately 30 cm from the other hand (control). In the second set just one hand of a subject was introduced in the cage each time. First one hand holding a turned-on device was introduced during 15 min. Then, the device was turned-off and after 5 min., the same hand was introduced again into the cage for 15 min. without the device.

The number of bites or initiated bites were counted for the experimental and control treatments in each test. Mosquitoes were not allowed to ingurgitate blood. Once landing on the hands and initiating a bite, they were induced to fly using a small feather on the tip of a rod.

A percent Protection Index (PI) was calculated based on Rutledge *et al.* (1985) and Combemale *et al.* (1992) as being PI=((PH-UPH)/PH) x100, where PH is the number of bites (or initiated bites) on the supposedly protected hand, and UPH is the same measure for supposedly unprotected hand. Differences in means were tested with ANOVA and least significant difference (LSD) test.

Table 2 presents the results for the two series of experiments.

The large number of bites a hand could receive during 15 min. exposure to caged *A. albopictus* was cleary shown. It is also clear that, despite a PI of 30.3% for Anti-Pic in the first test, the ultrasonic devices gave no consistent protection. The repellency seemingly promoted by the Anti-Pic, if real, could result from its lower harmonic peak (cf. Table 1), but the second set of tests failed to confirm this result. In fact, the mean number of bites during the second set of tests was higher than in this first, indicating a stronger but proportional increase in attack rate for protected (3.0) and unprotected (2.7) hands. When evaluating chemical repellents such as the DEET (Diethyltoluamide), we have unequivocally experienced in similar situations more than 300 bites/15 min. and 100% PIs (unpublished).

Singleton (1977), Belton (1981) and Foster & Lutes (1985) have evaluated 11 devices, ranging from 2 to 60 kHz and with harmonic peaks from 4 to 68 kHz. They checked for sound levels at different distances and evaluated repellency against *A. aegypti, Culex pipiens* L., *Anopheles quadrimaculatus* Say, *A. triseriatus* and *Haemagogus equinus* Theobald under field and laboratory conditions. No device succeeded in measurably repelling mosquitoes. Indeed, Curtis (1986) stated that two brands of buzzer sold as mosquito repellents have been taken off the British market after prosecution under the Trades Descriptions Act.

Bats are nocturnal predators and dengue vector mosquitoes such as *A. aegypti* and *A. albopictus* are diurnal, being in fact less sound oriented when compared to nocturnal mosquitoes. Indeed, sounds has been pointed as the way male

Table 2. Mean number of *A. albopictus* bites in 15 min., standard deviation (SD) and Protection Index (PI) for experiments where **both hands** were exposed one with and one without an electronic repellent device, or just **one hand** were exposed, at first with and then without the device (PH: supposedly protected hand, UPH: supposedly unprotected hand, n: replicates).

	Both hands in the cage				**One hand** in the cage			
		Mean number of bites (SD)				Mean number of bites (SD)		
Device	n	PH	UPH	PI (%)	n	PH	UPH	PI (%)
A-Pic	6	58.0 (14.2) a	83.2 (22.2) b	30.3	3	176.0 (129.2) a	228.0 (210.4) a	-
M-Re	5	72.6 (44.1) c	73.8 (32.1) c	-	3	306.6 (128.6) b	374.3 (176.6) b	-
BB-M								
(1)[1]	3	82.3 (48.5) d	45.0 (16.3) d	-	3	114.0 (6.2) c	123.6 (15.1) c	-
(5)	3	60.3 (41.0) e	43.3 (9.8) e	-	3	133.0 (25.7) d	156.0 (84.1) d	-
(10)	3	51.6 (21.1) f	56.3 (21.8) f	-	3	75.3 (24.0) e	80.3 (31.3) e	-

[1] Position of the 1-10 regulating switch. The difference of values followed by the same letter for each test are not significant (P>0.05).

mosquitoes are attracted to females (Belton 1994), and at least Wishart & Riordan (1959) indicated that a sound decreasing from a high to a low intensity could probably attract *A. aegypti* males that would otherwise be repelled by a constant high-level sound. According to Belton (1994), the potential for exploiting the attraction of the males to the sound of the female in flight has understandably been neglected. An approach directed to male attraction could be useful for population control strategies but not for bite reduction or dengue transmission by the females.

As a conclusion, and considering that the three presently available electronic devices failed to reduce human/mosquito contact and bites, they seem to be useless for dengue avoidance or even relief from the discomfort and distraction of *A. albopictus* biting. It could be also indicated the need of some governmental control upon the matter demanding tests and trade licences for such devices.

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