EFFECTS OF MICROWAVE RADIATION ON HOUSE DUST MITES, *DERMATOPHAGOIDES PTERONYSSINUS* AND *DERMATOPHAGOIDES FARINAE* (ASTIGMATA: PYROGLYPHIDAE)

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Abstract. *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* mites are commonly found in house dust, and are important sources of allergens affecting humans. Various approaches to killing the mites have been examined. This study investigated the mortalities of adult mites exposed to 2,450 MHz microwave radiation produced by 3 ovens at various exposure times and power settings. The ovens all had 3 power settings. The average maximum water temperatures generated at high, medium and low power settings were 99.4 ± 0.2, 84.1 ± 0.4 and 44.8 ± 0.9ºC, respectively. At high and medium settings, there was 100.0% mortality in both species when exposed for 300 seconds. The mean mortality rates at low power were 10.8 ± 0.7% for *D. pteronyssinus* and 9.7 ± 2.6% for *D. farinae*. When mites were exposed in the presence of culture media, the mortality rates decreased with increasing weight of media. The mean mortality with the largest amount of media tested at high power setting was 61.4%.

Key words: *Dermatophagoides pteronyssinus*, *D. farinae*, house dust mites, microwave radiation

INTRODUCTION

Some mites of the genus *Dermatophagoides* are recognized as major sources of house dust allergens (Voorhost *et al*, 1964). House dust mites can cause allergenic diseases, such as asthma and allergic rhinitis. *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* are two of the most important species of house dust mites found throughout the world and in Malaysia (Bronswijk and Sinha 1971; Mariana *et al*, 2000).

Multiple strategies have been developed to reduce mites and their allergens in homes using chemical and physical approaches. Several chemicals have been examined in laboratories and used to kill house dust mites (Dietemann *et al*, 1993). Although the use of acaricidal chemicals remains an essential component of control strategies, *D. pteronyssinus* and *D. farinae* may develop resistance to them (Warchalewski *et al*, 2000). Physical methods are becoming more widely investigated as alternatives or adjuncts to acaricidal chemicals for the killing of mites and insects, including the use of ionizing and non-ionizing radiation (Watters, 1991).

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High frequency microwaves can penetrate objects creating heat (Wang and Tang, 2001). Microwave radiation can affect living organisms in different ways; high intensity radiation is lethal due to its thermal effect on living tissue (Ondracek *et al*, 1976). When plant or animal tissue having a high water content, makes contact with microwave radiation, the water molecules react to cause ripping of tissue. Much research has been done on the effects of ionizing radiation for various species of insects and mites during various developmental stages. Fanslow *et al* (1975) demonstrated that microwave radiation at 2,450 MHz destroys the eggs of the Southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber. Microwave radiation at 460 MHz can delay larval development in some insects, such as *Drosophila melanogaster* (Meigen) (Bol'shakov *et al*, 2001). The precise dosage and time of treatment needed to kill or sterilize some insects and mites has been determined (Banks and Fields, 1995).

There is no literature on the effect of microwave radiation on house dust mites. This study aimed to investigate the effects of radiation from 3 microwave ovens on adult *D. pteronyssinus* and *D. farinae* dust mites.

MATERIALS AND METHODS

Source of mites

Adult male and female *D. pteronyssinus* and *D. farinae* were obtained from colonies established since 1960 in the Acarology Unit, Institute for Medical Research (IMR), Malaysia. The colonies are reared in small glass bottles and sterile ground rat chow is used as culture medium. All bottles were kept in desiccation jars containing a solution of saturated sodium chloride (NaCl) to maintain a relative humidity (RH) of 75 ± 3% at an average temperature of 25 ± 2ºC.

Microwave ovens

Three 2,450 MHz microwave ovens, SANYO® (EM-240), SHARP® (R-218L), and PANASONIC® (NN-S215MF/WF), were used for the study. The ovens had 3 power settings; low, medium and high. Water temperature generated at low, medium and high settings was determined by placing a 500 ml glass beaker containing 300 ml of distilled water in the ovens and exposing it for 10 to 300 seconds at each of the 3 power settings. The temperature of the water immediately after exposure was recorded. That process was repeated 3 times for each power setting and exposure time.

Method of exposure - no culture medium

Thirty adult male and female mites were placed in clean glass Petri dishes, 9.0 cm diameter and 1.2 cm high. The Petri dishes and mites were next placed inside the microwave ovens and exposed to the various power settings (high, medium and low) with plate rotation for times ranging from 30 to 300 seconds. Controls were similarly treated except the ovens were not switched on. Three replicates were tested for each power setting and exposure time. The exposed mites were examined at 400x magnification and the number of dead mites was recorded; mites that do not move when gently prodded were considered dead.

Method of exposure - with culture medium

Ten adult *D. pteronyssinus* or *D. farinae* mites were placed in clean glass Petri dishes, 9.0 cm diameter along with 0.01 - 0.25 g of sterile culture medium. The Petri dishes were then placed inside the microwave ovens and treated at the high and medium setting for various exposure times. Controls were similarly prepared but placed in the ovens that were not switched on. There were 5 replicates for

Table 1
Water temperature generated by 2,450 MHz microwave radiation.

Power setting	Exposure time (seconds)	Number of replicates	Mean temperature ± SD (°C)		
			Sanyo	Sharp	Panasonic
Low	10	3	22.3 ± 0.4	25.3 ± 0.5	27.0 ± 0
	30	3	22.7 ± 0.3	34.6 ± 0.5	29.3 ± 0.5
	60	3	23.3 ± 0.3	35.3 ± 1.1	32.2 ± 0.5
	120	3	24.8 ± 0.3	41.0 ± 1.7	35.6 ±1.5
	300	3	31.9 ± 0.2	50.3 ± 0.5	52.3 ± 2.0
Medium	10	3	23.0 ± 0.8	31.6 ± 0.5	30.3 ± 0.5
	30	3	27.0 ± 0.7	38.4 ± 0.5	35.6 ± 1.5
	60	3	32.8 ± 0.8	39.4 ± 0.5	51.6 ± 0.5
	120	3	38.9 ± 0.7	51.3 ± 1.5	68.0 ± 0.3
	300	3	66.6 ± 0.4	98.3 ± 0.5	87.3 ± 0.5
High	10	3	23.2 ± 0.3	32.2 ± 1.1	31.6 ± 0.5
	30	3	29.1 ± 0.9	41.6 ± 0.5	38.3 ± 0.5
	60	3	38.7 ± 0.4	62.0 ± 1	51.3 ± 1.1
	120	3	53.2 ± 0.6	97.0 ± 1	89.3 ± 0.5
	300	3	98.3 ± 0.8	100.0 ± 0	100.0 ± 0

each treatment and the procedure was repeated 3 times. A total of 150 mites were tested for each species and exposure time. The number of dead mites after treatment was examined at 400x magnification and the mortalities were recorded.

Data analysis

Mean mortalities were compared and analyzed by ANOVA. For data that was not normal, the Friedman test (*F*-test) was used (Sheridan and Lyndall, 2002).

RESULTS

The water temperatures generated at the various power settings and exposure times for all brands of microwave are shown in Table 1. Water temperature generated by the Sanyo oven was relatively lower than the Panasonic and Sharp ovens. Mean water temperatures were significantly different between the ovens ($p<0.01$) at the low power setting but not at the medium and high power settings ($p>0.05$).

Mortality rates of *D. pteronyssinus* and *D. farinae* treated at various power settings and exposure times for the different ovens are shown in Fig 1 and 2. No mites died in the controls. Generally, mortality rates increased with increasing power and exposure times for all three ovens. At high and medium settings for 300 seconds exposure, 100% mortality was seen in all ovens for both species of mites. For similar exposure times at low power settings, there was no significant difference among ovens in the highest mean mortality rate found with each species ($p>0.08$); the mean mortality rates were 9.7 ± 2.6% for *D. farinae* and 10.8 ± 0.7% for *D. pteronyssinus*. However, the mean mortality rates by species were significantly different from each other ($p = 0.03$).

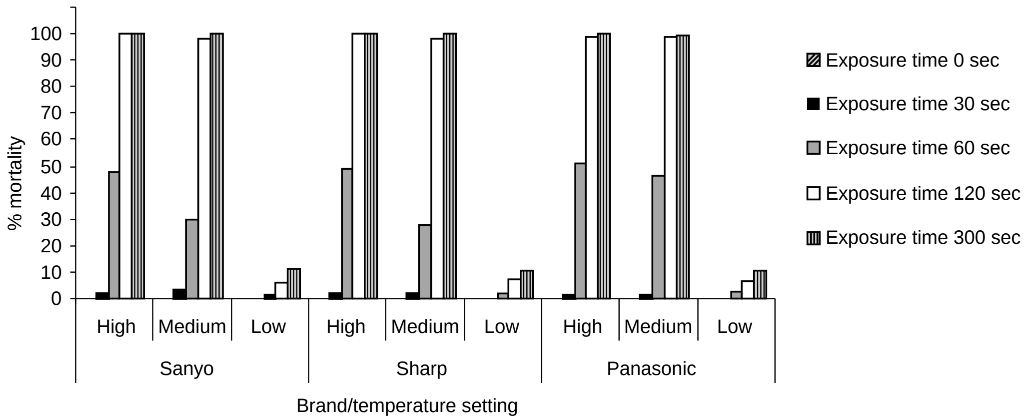

Fig 1–Mortality rates of adult *D. pteronyssinus* exposed to 2,450 MHz microwave radiation at various power settings in 3 ovens.

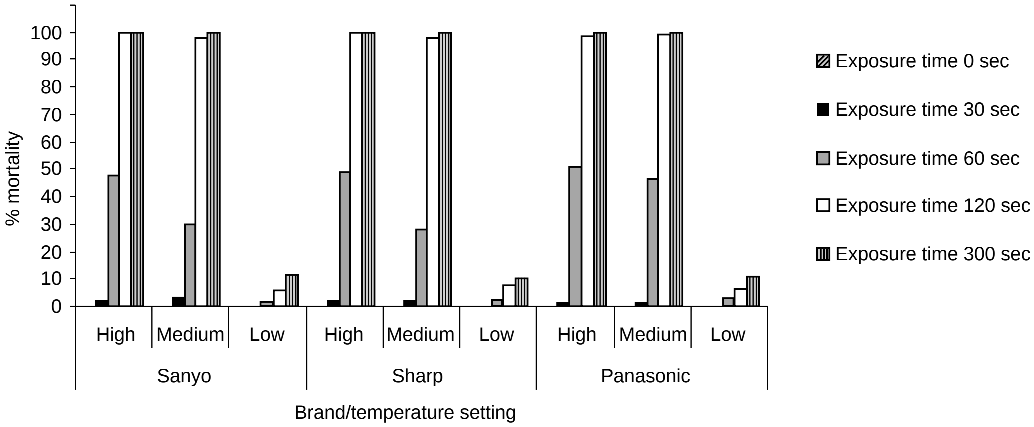

Fig 2–Mortality rates of adult *D. farinae* exposed to 2,450 MHz microwave radiation at various power settings in 3 ovens.

There was no significant diffrence ($p > 0.20$) in mean mortality rates at 120 seconds and 300 seconds exposure for *D. pteronyssinus* in all ovens at both high and medium power setting. For *D. farinae*, the difference was not significant in all ovens at the high power setting ($p > 0.10$), but at the medium power setting the difference between the Sharp and Sanyo ovens was significant ($p > 0.01$).

Overall, the mean mortality rates of the mites in the culture medium decreased with increasing amount of medium, and increased with increasing exposure times. There were no deaths in controls. The mortality rates at the high power setting for the longest exposure time studied (300 seconds) are shown in Tables 2 and 3.

At high power, all the ovens produced near 100% mortality rates in the presence of the lowest amount of media (0.01 g) for both mite species. At the maximum amount of medium studied (0.25 g), there was no significant difference ($p > 0.09$) in

Table 2
Mortality rates of *D. pteronyssinus* in the presence of culture medium exposed for 5 minutes at high power in various microwave ovens.

Oven	Weight of medium (g)	% Mortality (mean ± SD)
Sanyo	0.01	100
	0.05	96.7 ± 3.3
	0.10	86.7 ± 3.3
	0.15	76.6 ± 8.8
	0.20	60.0 ± 3.3
	0.25	51.1 ± 5.1
Sharp	0.01	100
	0.05	100
	0.10	93.3 ± 3.3
	0.15	74.4 ± 7.6
	0.20	68.9 ± 1.9
	0.25	58.9 ± 8.3
Panasonic	0.01	100
	0.05	99.6 ± 0.6
	0.10	93.3 ± 4.7
	0.15	87.0 ± 7.2
	0.20	73.3 ± 8.8
	0.25	61.4 ± 8.4

Table 3
Mortality rates of *D. farinae* in the presence of culture medium exposed for 5 minutes at high power in various microwave ovens.

Oven	Weight of medium (g)	% Mortality (mean ± SD)
Sanyo	0.01	100
	0.05	98.9 ± 1.9
	0.10	84.4 ± 7.6
	0.15	78.7 ± 5.0
	0.20	56
	0.25	37.8 ± 1.6
Sharp	0.01	100
	0.05	99.6 + 0.6
	0.10	93.3 + 3.3
	0.15	76.7 + 5.7
	0.20	68.9 ± 1.9
	0.25	57.7 ± 1.9
Panasonic	0.01	99.6 ± 0.6
	0.05	99.6 ± 0.6
	0.10	94.0 ± 3.5
	0.15	77.8 ± 3.8
	0.20	60.6 ± 5.2
	0.25	48.9 ± 1.9

mean mortality rates among the 3 ovens; the combined mean mortality rate was 57.1 ± 7.7% for *D. pteronyssinus* and 48.1 ± 11.7% for *D. farinae*. The difference in mean mortality rate was not significant ($p > 0.09$) between species among the ovens.

DISCUSSION

Much research has been done regarding the lethal and sterilizing effects of ionizing radiation on various species of insects and mites. The direct absorption of microwaves is highly effective in killing mites because of the heat generated due to high frequency oscillation of dielectric molecules, such as water and body fluid of mites. The findings of this study indicate direct exposure of *D. pteronyssinus* and *D. farinae* to 2,450 MHz ovens at high power setting for more than 120 seconds, results in nearly 100% lethality. Water boils at this level of exposure. Sripakdee *et al* (2005) conducting a similar study with blow flies and reported no flies survived when larvae were exposed to 2,450 MHz microwave oven for 60 seconds at medium setting. Although microwave radiation can kill dust mites, its application to control of such mites in their natural habitat, such as mattresses or carpet, is not yet practical.

One possible application of microwave radiation on dust mites is rapid decontamination of infested stored products.

The findings here demonstrate the stored products or ground rat chow hinder the penetration of the microwave radiation resulting in lower mortality rates than if the mites were directly exposed. Since mortality rates increase with increasing exposure times, increasing exposure to more than 5 minutes may result in higher mortality rates. However, there is a need to balance the effect on the mites with the effect on the stored product, since prolonged exposure to intense radiation may damage products. In their study on the effect of microwave radiation on stored-product insects, Shayesteh and Barthakur (1996) stated the heat generated by the radiation of the product has an impact upon the insects. Although mortality rate decrease with increasing culture medium, if the quantity of medium is sufficiently large, the heat generated by the medium on exposure to microwave radiation may be transferred to any mites present in the medium, causing mite death.

This study focused on mortality induced by microwave radiation. Besides killing mites, the radiation also affects the development and reproduction of arthropods. Mites that are not killed on initial exposure to microwave radiation may not be able to develop or reproduce, having a secondary effect on mite population. Besides the effect on live dust mites, the radiation may denature dust mite allergens. This needs to be further investigated as a holistic approach to the use of microwaves for control of dust mites and their allergens.

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