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Effect of a commercial air ionizer on dust mites *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* (Acari: Pyroglyphidae) in the laboratory

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ABSTRACT

Objective: To investigate the short and long term efficacy of a commercial air ionizer in killing *Dermatophagoides pteronyssinus* (*D. pteronyssinus*) and *Dermatophagoides farinae* (*D. farinae*) mites. **Methods:** The effect of a commercial ionizer on *D. pteronyssinus* and *D. farinae* was evaluated in the laboratory, using a specially designed test. Mortality was assessed after 6, 16 and 24 hours for direct exposure and after 24, 36, 48, 60 and 72 hours for exposure in simulated mattress. New batches of mites were used for each exposure time. **Results:** LT_{50} for direct exposure of ionizer was 10 hours for *D. pteronyssinus* and 18 hours for *D. farinae*. The LT_{50} for exposure in simulated mattress was 132 hours or 5.5 days for *D. pteronyssinus* and 72 hours or 3 days for *D. farinae*. LT_{95} for direct exposure of ionizer was 36 hours for *D. pteronyssinus* and *D. farinae*. Meanwhile, the LT_{95} for exposure in simulated mattress was 956 hours or 39.8 days for *D. pteronyssinus* and 403 hours or 16.8 days for *D. farinae*. **Conclusions:** This study demonstrates the increasing mite mortalities with increasing exposure time of a commercial ionizer and suggests that negative ions produced by an ionizer kill dust mites and can be used to reduce natural mite populations on exposed surfaces such as floors, clothes, curtains, *etc*. However, there is reduced efficacy on mites inside stuffed materials as in mattresses and furniture.

1. Introduction

Mites represent the main source of allergens in humid areas and sensitization to their allergens is a major risk factor for asthma in exposed individuals. Mite allergens sensitize and induce perennial rhinitis, asthma, or atopic dermatitis in a large portion of patients with allergic disease. There is convincing evidence that avoidance of mite allergen can effectively reduce allergic symptoms[1,2]. Mite avoidance measures, such as washing bedding in hot water, encasing mattresses and pillows in allergen impermeable covers and woven material covers, maintaining room humidity below 50% relative humidity, removing carpets and vacuum cleaning can reduce exposure to mite allergen[3,4]. In addition, various chemicals such as benzyl-benzoate, tri-n-butyl tin maleate, diethyl-m-toluamide (DEET) and dibutylphthalate have been applied in attempts to control the mite populations[5,6].

Air sterilizers or ionizers may offer a simple, efficient and inexpensive way to reduce allergen levels in the domestic environment[7]. There has recently been a great increase in interest and availability of air sterilizers for use in both home and work environments. Early research focused on the ability of ionizers to electrostatically precipitate airborne dust and allergens[8]. The direct actions of negative and positive ions on the respiratory system have also been investigated[9]. The product of corona discharge, the process by which ionizers produce ions, was reported to destroy the major house dust mite allergen Der p 1. Negative corona produced a greater percentage reduction in Der p 1 concentration when a higher voltage was applied[10].

Many types of ionizers are now available that have improved efficiency to reduce airborne allergens and clean the air. However, to date there is no published data to show that ions discharged by such ionizer are acaricidal. The aim of this study is to investigate in the laboratory, short and long term efficacy of a commercial air ionizer in killing *Dermatophagoides pteronyssinus* (*D. pteronyssinus*) and *Dermatophagoides farinae* (*D. farinae*) mites.

2. Materials and methods

2.1. Mites

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D. pteronyssinus and *D. farinae* mites from colonies established since 1960s in the Acarology Unit, Institute for Medical Research, Malaysia, were used. The colonies were reared in small glass bottles and fed with ground rat chow. All colonies were maintained at an average temperature of (25±2) ℃ and 75% relative humidity.

2.2. Device

A Medklinn™ air ionizer was used (Figure 1). The product adopts a patented process called 'Non-Thermal Plasma' technology that converts neutral oxygen molecules into negatively charged oxygen atoms or 'negative ions'. There is an emission rate of 3 million negative ions per second. The amount of ozone emission is controlled to below 0.05 ppm. In the present study, the ionizer was used at its maximum emission rate.

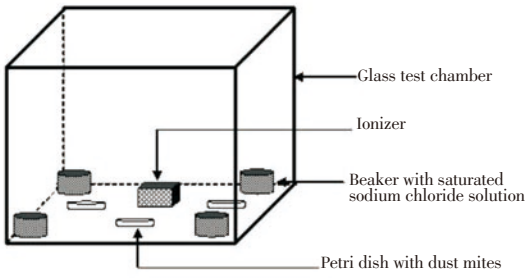

Figure 1. Expetimental setup to study direct effect of an ionizer on house dust.

2.3. Bioassay

2.3.1. Direct exposure

The ionizer was placed inside a cubic glass test chamber (60 cm × 60 cm × 60 cm) and maintained at 75% RH (using saturated sodium chloride solution) and 25 ℃. The experiment set-up was shown in Figure 1. Thirty 15-25 days old adult mites of mixed males and females were placed on a square Whatman No. 1 filter paper (9 cm × 9 cm) attached to the bottom of a 14 cm diameter plastic Petri dish. Doors to the glass chamber were then secured and the ionizer was switched on. The ionizer was not switched on in control chambers. A total of 15 replicates were tested for both treatment and control per exposure time. Mortalities of mites were assessed after 6, 16 and 24 hours exposure. Mites that were motionless when probed gently with a sharpened wooden application stick were considered dead.

2.3.2. Exposure in simulated mattress

The same experimental set-up used above for studying the direct effect, was used except each Petri dish containing mites was sandwiched between two layers of foam (20 cm × 20 cm × 4.5 cm) to simulate mattresses. All sides of the foam sandwich was sealed with masking tape. A total of 12 replicates were tested for both treatment and control per exposure time. Mortalities of mites were assessed after 24, 36, 48, 60 and 72 hours exposure to ionizer.

2.4. Statistical analysis

Percent mortality was recorded for each time interval. Lethal times (LT_{50} and LT_{95}) were determined by Probit analysis (11) using SPSS ver. 13.0 (SPSS, Chicago, IL). Differences of means were analyzed using T-test and ANOVA at 95% confidence level.

3. Results

Mean mortalities from direct exposure were presented in Figure 2. At 6 hours exposure, (39.00±8.85)% and (13.00±3.09)% mortalities were recorded for *D. pteronyssinus* and *D. farinae*, respectively. About (63.00±11.46)% and (45.00±12.44)% mortalities were recorded for *D. pteronyssinus* and *D. farinae*, respectively after 16 hours exposure. Mean mortalities then increased to (82.00±11.80)% and (70.00±8.77)% for *D. pteronyssinus* and *D. farinae*, respectively at 24 hours exposure. The mean mortalities for each species were significantly different ($P<0.05$) between exposure times. There was significant difference in mean mortalities between species at 6 and 16 hours exposure ($P=0.00$, $P=0.02$) but not at 24 hours exposure ($P=0.22$).

Mean mortalities in simulated mattresses were presented in Figure 3. The mortalities for *D. pteronyssinus* after 24, 36, 48, 60 and 72 hours exposure were (6.00±0.98)%, (16.00±2.31)%, (21.00±7.32)%, (26.00±2.81)% and (29.00±7.43)% respectively, whereas they were (7.00±1.75)%, (20.00±4.50)%, (26.00±4.53)%, (41.00±7.89)% and (65.00±5.47)%, respectively for *D. farinae*. The mean mortalities at each exposure time were significantly different between species ($P<0.05$). Analysis by ANOVA indicated the mortalities were significantly different between exposure times ($P<0.01$) for each species of mite. The increase in mortalities for *D. pteronyssinus* from 24 to 72 hours was gradual, whereas for *D. farinae*, the increase was gradual from 24 to 48 hours exposure time after which there was a spike to 72 hours.

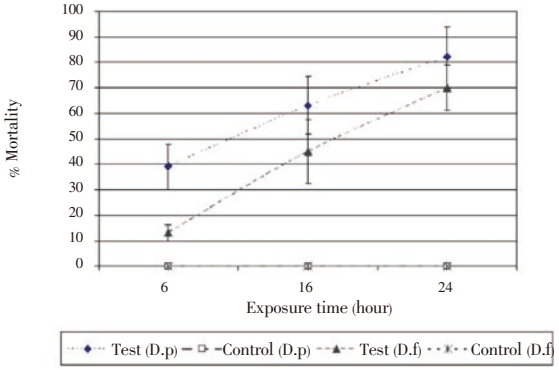

Figure 2. Mean mortalities of *D. pteronyssinus* (D.p) and *D. farinde* (D.f) mites from direct exposure to a commercial ionizer.

The lethal times in simulated mattress were longer than

Table 1
Lethal times of *D. pteronyssinus* and *D. farinae* mites exposed to an ionizer (95% confidence interval expressed in parentheses).

Species of mite	Direct exposure			Simulated mattress		
	LT_{50} (hour)	LT_{95} (hour)	Regression equation	LT_{50} (hour)	LT_{95} (hour)	Regression equation
D. pteronyssinus	10 (9-12)	36 (33-40)	$Y= -0.68 + 0.07X$	132 (108-180)	956 (546-2327)	$Y= -4.06 + 1.91X_1$
D. farinae	18 (17-19)	36 (34-39)	$Y= -1.64 + 0.09X$	72 (66-82)	403 (197-400)	$Y= -5.56 + 2.97X_1$

Y = probit (mortality); X = time; $X_1 = \log_{10}$ time.

those from direct exposure. LT_{50}s and LT_{95}s as calculated by probit analysis were shown in Table 1. Direct exposure LTs were similar for both mites. However, LTs for exposure in simulated mattress were higher for *D. pteronyssinus* than *D. farinae*.

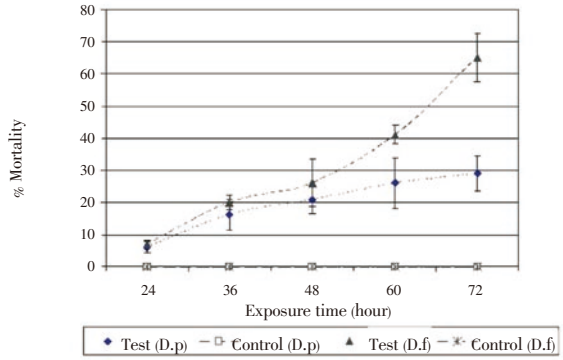

Figure 3. Mean mortalities of *D. pteronyssinus* (D.p) and *D. farnae* (D.f) mites in simulated mattress and exposed to a commercial ionizer.

4. Discussion

It is clear that more mites are killed and in a shorter time, by the ionizer (MedklinnTM) on direct exposure than in simulated mattress. This is to be expected as in direct exposure, the negative ions produced from the ionizer, directly impacts upon the mites without any hindrance. In simulated mattress, the ions needed to penetrate the foam material before impacting upon the mites. It appears that the amount of ions reaching the mites in simulated mattress may be reduced by the foam material. Experiments have been performed by Goodman into determining the extent of corona product, the process by which ionizers produce ions, penetration through different fabrics and foam used in soft furnishings and the results have shown that the corona products penetrate only poorly through fabric and foam to where the main Der p1 allergen reservoirs are found. In that study, the least reduction of dust mite allergen was observed with only 10 mm of closed cell foam[12].

The results showed increasing mite mortalities with increasing exposure time. The study device is designed for 24 hours non-stop operation and thus higher mite mortalities can be expected after days of continuous exposure. The poorer response from *D. pteronyssinus* indicates that different mite species will respond differently. It is unclear why this is so and therefore it needs further investigation. However, the use of ionizer continuously throughout the day is not recommended due to the fact that exposure to ozone is harmful, especially to individuals with allergies[13,14]. Therefore, more research on scientific and clinical benefits of ionizer is necessary to conduct before translating well into the practical application in real environment condition particularly the impact on allergy patients.

The findings of this study suggest that negative ions produced by an ionizer kill dust mites and can be used to reduce natural mite populations on exposed surfaces such as floors, clothes, curtains, *etc*. This assumption is strongly supported by previous studies indicating that ozone, a product of corona discharge in air, has been reported to kill a number of organisms including insect[15]. However, there is reduced efficacy on mites inside stuffed materials as in mattresses and furniture. Thus, the use of such ionizers in bedrooms can contribute to the reduction of exposure to dust mites and their allergens by denaturing the allergens as well as killing the mites.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

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