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Controlling Allergens in Animal Rooms By Using Curtains

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The reduction and control of allergens in the animal facility is important for staff working with laboratory animals. This study was designed to evaluate the efficiency of perforated Makrolon curtains in front of racks as a method to reduce the amount of allergen in the animal room. The experimental situation we studied provides some information regarding allergen disposition in animal rooms but is clearly artificial and does not reflect a typical, 'real-world' environment in terms of preventing exposure of workers to allergens. Plastic curtains with holes were placed in front of racks, and a corridor between the racks and a curtain was present. The room was ventilated with air, which was blown into the room through the middle of the corridor, flowing downstream and passing through the holes in the curtain. This set-up resulted in air flow from the corridor through the curtain. Air samples were collected from sites in the corridor and behind the curtain. The samples were analyzed for the allergen Mus m1, and the amount of allergen was calculated. The results show air flow from the aisle through the holes in the curtains and through the racks behind the curtains, and this flow keeps allergen behind the curtains and prevents its spread from the cages into the aisle. The present study shows that the use of curtains in front of the cage racks is an efficient way to prevent spread of allergens from rodent cages to the entire animal room.

Abbreviation: ELISA, enzyme-linked immunosorbent assay

In recent years the occupational disease of laboratory animal allergy has received increasing attention, and various initiatives have been undertaken to reduce the spread of allergens from animals. For greatest efficacy, allergens must be reduced and controlled as close to the source as possible so that a minimal space, rather than the entire animal facility, is contaminated. In addition, the spread of allergens throughout the facility induces a risk of further spread to other parts of the building. Housing rodents in individually ventilated caging systems or ventilated cabinets can markedly reduce the spread of allergens, especially if the cages or cabinet are ventilated with negative pressure relative to the surroundings.[5,7] Another way to reduce the spread of allergens close to the source is by using curtains in front of the cage racks. Combined with a correct flow of air from the aisle through the curtains, allergens may be kept behind them and prevented from spreading to aisles.[4] The curtain system is analogous to ventilated cabinets, but rather than being on wheels, curtains are permanent fixtures in the animal room. Compared with ventilated cabinets, curtains are easy to install and use in existing facilities and are very flexible, as anything and any animal species can be placed behind curtains.

Only a few studies[4,8] have been conducted to evaluate the efficiency of curtains in animal room in relation to preventing the spread of allergens, and no published study has involved mice. No animal smell can be detected in the aisles of animal rooms with curtains, perhaps indicating that the curtains are effective. A previous study measuring allergens from rats in an animal room with curtains concluded that the curtains effectively prevented the spread of allergens from the cage rack to the surroundings.[4]

The aim of the present study was to evaluate the efficiency of plastic curtains installed in animal rooms for mice in which there was no research activity and minimal husbandry activity. We determined the spread of allergen through the curtains into the aisle and estimated the allergen level behind the curtains. We also measured the humidity and temperature of the room and the speed of the air moving from the aisle through the holes in the curtains.

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Materials and Methods

Animals and animal rooms. Perforated transparent Makrolon curtains (Scanbur-BK, Copenhagen, Denmark) were installed in an animal room at Sanofi-Aventis (Frankfurt, Germany; Figure 1). Each curtain measures 991 × 1835 mm and has 45 holes (diameter, 40 mm) in 8 rows. Each side of the room has 6 curtains placed in front of the cage racks. In the room, 488 transgenic mice of different strains and sex were housed according to European legislation in 116 Type III cages (42 × 27 × 12 cm, Tecniplast, Buguggiate, Italy) placed in 9 racks and with health status according to Federation of European Laboratory Animal Science Association guidelines. All cages were changed twice weekly, and all cages had hardwood bedding (Lignocel, HBK 1500-3000, J Rettenmaier and Söhne, Rosenberg, Germany) and food pellets ad libitum (Ssniff R/M-H, Ssniff Spezialdiäten, Soest, Germany), tap water by bottle ad libitum, and enrichment items (wooden blocks, wood wool, and gnawing sticks). The animals in the room were used for chronic studies, with no researcher activities in the rooms and a constant number of animals over the entire study period. The only activities taking place in the rooms were daily routine animal care activities.

Allergen measurements. Four measuring points (Figure 2) were selected: 2 on the left side of the room behind the curtains (A and B), and 2 in the aisle in front of the curtains (C and D). Points A and C were 175 cm above the floor ('at roof'), and points B and D were 50 cm above the floor ('at floor').

Allergen samples were collected on 1.0-µm filters (FALP

Figure 1. The curtains in front of the racks with the mouse cages.

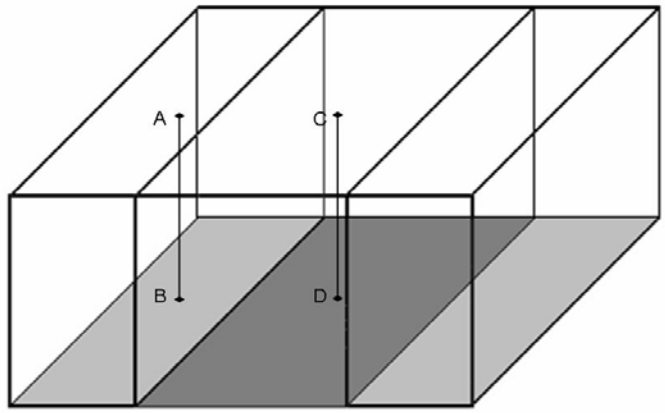

Figure 2. The positions of the 4 measuring points.

02500, Millipore, Copenhagen, Denmark) by using a pump (AirCheck 2000, SKC, Eighty Four, PA) at a flow rate of 2.0 l/min. Sampling time was 30 min per sample; sampling was delayed 30 min to ensure that the air and amount of allergen had stabilized after the room was disturbed due to entering the room and setting up the pumps. Eight samples were taken from each point daily. Allergen was collected in the morning from 0930 to 1200, and in the evening at 0400 and 0430, and the measurements were done 2 d after cage changing. The samples were collected over a period of 4 wk.

The method used for elution of the filters was adopted from an established method.[6] After sampling, the filters were placed in a 1.5-ml microfuge tube and eluted in 1.0 ml phosphate buffered saline containing 0.5% Tween 20. Filters were washed for at least 2 h to ensure that all allergen was washed off the filters. The eluate then was collected by centrifugation, and 0.1 heat-fractioned bovine serum albumin (catalog no. A7030, Sigma–Aldrich Denmark, Copenhagen, Denmark) was added to each sample. Then the samples were stored at –20 °C until analysis.

After thawing, samples were analyzed for allergen levels by enzyme-linked immunosorbent assay (ELISA) by using the Mus m1 ELISA Kit (Indoor Biotechnologies, Manchester, United Kingdom). The manufacturer's protocol was used, except that signals were visualized by using ortho-phenyldiamine (catalog no. S2045, DakoCytomation, Copenhagen, Denmark) and reading at 492 nm, with 630 nm as reference. All samples were tested twice: as undiluted samples and as 1:5 dilutions. The lower detection limit for the samples in the present study, recalculated from the air-sampling and ELISA results, was 0.2 ng/m^3.

Temperature, humidity, and air speed through curtains. Temperature and humidity at each of the measuring points were measured 3 times every 30 min from 1000 to 1200 and from 0400 to 0500 for 3 d. The measurements were done with a Hobo 4-channel Measurement system (Synotech, Linnich, Germany).

The device for measuring air speed (model 400, Testo, Lenzkirch, Germany) was placed in the middle of the holes on the inside of the curtain, and 3 measurements were taken for each hole. Three curtains in each room were selected, and for each curtain, 3 holes were selected: 1 at the top, 1 in the middle, and 1 at the bottom of the curtain.

Data analysis. The data from the allergen measurements were not normally distributed, therefore we used the nonparametric Mood median test (Minitab release 14, Minitab, State College, PA). In the test, the nondetectable level was set to 0.2 ng/m^3.

The data from the air speed measurements were normally distributed and therefore were tested with *t* tests; temperature and humidity data were normally distributed and tested with paired *t* tests (Minitab release 14, Minitab).

Results

Allergen was present behind the curtain at both day and night and ranged from less than 0.2 to 3.33 ng/m^3 (Table 1). In front of the curtains, no allergen could be detected. There was a significant ($P < 0.001$) difference between the amount of allergen in front of the curtains compared with behind the curtains.

Temperature and humidity were the same behind and in front of the curtains (Table 2), ranging from 20.4 to 21.7 °C and from 48.3% to 56.8%, respectively. The temperature at the roof was significantly ($P < 0.05$) higher than at the floor, and humidity ($P < 0.001$) was significantly higher at the floor than at the roof. This pattern was the same for both night and day.

Air speed through the holes in the curtains from the outside to the inside of the curtains was consistent, with an air speed of 0.28 m/s for all 3 positions (Table 3). There were no significant differences in air speed at the different positions.

Table 1. Measured allergen levels in front of and behind curtains

	Day		Night	
	Mean Mus m1 (ng/m^3)	Range (ng/m^3)	Mean Mus m1 (ng/m^3)	Range (ng/m^3)
Behind curtain, at roof	0.57	<0.2–1.48	1.22	0.34–3.33
Behind curtain, at floor	0.89	0–3.07	0.3	<0.2–0.96
In front of curtain, at roof	Not detectable		Not detectable	
In front of curtain, at floor	Not detectable		Not detectable	

n = 8 for all test conditions.
There was a significant ($P < 0.001$) difference between the amounts of allergens in front of the curtains compared with behind them.
The minimum detection level for the Mus m1 ELISA was 0.2 ng/m^3.

Table 2. Temperature and humidity in front of and behind curtains

	Day		Night	
	°C	Humidity (%)	°C	Humidity (%)
Behind curtain, at roof	21.7 ± 0.0	54.1 ± 1.8	21.4 ± 0.1	48.3 ± 6.6
Behind curtain, at floor	20.8 ± 0.2	55.7 ± 2.0	20.4 ± 0.2	49.6 ± 6.8
In front of curtain, at roof	21.3 ± 0.0	54.2 ± 1.8	20.5 ± 0.1	50.1 ± 6.9
In front of curtain, at floor	20.7 ± 0.2	56.8 ± 2.1	20.4 ± 0.2	51.0 ± 7.0

Data are presented as mean ± 1 standard deviation; n = 9 for all test conditions.
During both day and night, temperature was significantly ($P < 0.05$) higher at the roof than at the floor, and humidity significantly ($P < 0.001$) higher at the floor compared that at the roof.

Table 3. Air speed through the holes in the curtains

Location of holes sampled (n = 9 for each)	Air speed through holes (m/s; mean ± 1 standard deviation)
Top row	0.28 ± 0.01
Middle row	0.28 ± 0.03
Bottom row	0.28 ± 0.01

There were no significant differences between the air speeds at different positions.

Discussion

The results for air speed show that there is air flow from the aisle through the holes in the curtains and between the racks behind the curtains. This flow is uniformly distributed through all the holes in the curtains, thereby ensuring that all racks are well-ventilated. In addition, this uniform flow ensures that there is always an inflow of air and that this flow is one-way.

The inflow of air from the aisle keeps allergen behind the curtains and prevents its spread from cages into the aisle, as also shown in other studies.[4,8] This directional flow ensures a clean aisle when the curtains are closed, similar to using ventilated cabinets.[7] Therefore no allergens can be detected in the aisle, not even during the night, when the spread of allergens from cages is highest. The experimental situation we studied provides some information regarding allergen disposition in animal rooms but is clearly artificial and does not reflect a typical 'real world' environment in terms of preventing exposure of workers to allergens.

The temperature measured at the roof was higher than the temperature at the floor; consequently, the humidity at the roof was lower than that at the floor. The higher temperature at the roof is due to the rising of warmer air and was seen especially behind curtains, where the animals' emission of heat increased the temperature of the air as it passed the cages.

One drawback to curtains is that, when opened for access to cages, allergens can be spread and, more importantly, if cages are changed in the same room, the amount of allergen spread from that procedure will be very high.[2] Therefore from an allergy point of view, the best practice is to perform cage changing and handling of animals on a ventilated bench or in a laminar-airflow cabinet, thereby keeping the allergens inside the bench or cabinet and reducing or eliminating the spread of allergens to the surroundings.[1,3] Limitations of the experimental design for purposes of extrapolation include avoiding cage changing, limiting activity in the room, and keeping curtains closed near the time of sampling.

In conclusion, the use of perforated Makrolon curtains in front of cage racks is an efficient way of preventing allergen spread from rodent cages into the entire animal room, and in this case the inflow of air was able to secure that all cages in the rack were well-ventilated.

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