

THE ABUNDANCE OF HOUSE DUST MITES (PYROGLYPHIDAE) IN DIFFERENT HOME TEXTILES IN EUROPE, IN RELATION TO OUTDOOR CLIMATES, HEATING AND VENTILATION

ANNE M.T. VAN NES, HELIANTHE S.M. KORT, L.G.H. KOREN, C.E.E. PERNOT,
H.L. SCHELLEN, F.E. VAN BOVEN, JOHANNA E.M.H. VAN BRONSWIJK
Centre for Biomedical and Health-Care Technology, Eindhoven University of Technology, PO Box 513, 5600 MB
Eindhoven, The Netherlands

Abstract—In Europe, house dust mites of the family Pyroglyphidae are abundant producers of allergens in dwellings. Their prevalence in dwellings as well as their distribution among different types of home textiles vary in different localities in Europe.

The main limiting factor for mite population growth is water activity. Water activity is closely related to relative humidity in the mite niche. Relative humidity in the mite niche is influenced by outdoor temperature and absolute air humidity, heating and ventilation.

The mean January outdoor air temperature was determined.

Based on outdoor temperatures and absolute air humidities, the length of heating season and length of mite population growth season for different home textiles were defined. These variables were validated with published data on mite abundance in mattresses and on floors in climatically distinct areas in Finland, Denmark, United Kingdom, The Netherlands, France, Switzerland, Italy and Poland.

Length of mite population growth season - abbreviated to mite season - can be shortened by effective ventilation. Therefore, minimal required ventilation rates, to keep the relative humidity in the mite niche below the hygienic moisture limit for mite population growth, in European countries, were collected.

No significant correlation was demonstrated between length of heating season and mite numbers in any of the home textiles.

Between mean January outdoor air temperature and mite numbers in mattresses; and between length of mite season and mite numbers in mattresses, significant correlations were seen (Spearman rank correlation test, $p < 0.05$). On floors, none of the climatic variables showed a significant correlation with mite numbers. Minimal required ventilation rates were found in Denmark and the Netherlands, only.

In contrast to length of heating season, mean January outdoor air temperature and length of mite season in mattresses can predict the overall abundance of house dust mites in mattresses in a climatic area. To predict the overall mite burden on floors, the influence of outdoor climate should be examined in combination with soil and constructional factors. To shorten the length of the mite population growth season minimal required ventilation rates have to be known.

INTRODUCTION

Prevalence of house dust mites (Pyroglyphidae) in dwellings as well as their distribution among different types of home textiles vary in different European countries¹⁻¹¹.

Exposure to house dust mite allergens may cause sensitization in persons with an atopic constitution, in Europe 20-40% of the total population (van Bronswijk, 1991).

The no-sensitization threshold for house dust mites has been set at 10 mites per gram floor dust or 100 mites per gram mattress/upholstery dust. For their major allergen *Der p 1* the no-sensitization threshold has been set at 2000 ng per gram dust (Platts-Mills and de Weck, 1989).

Mite population growth depends mostly on water activity. Water activity correlates closely to relative air humidity in the mite niche. When relative humidity in the mite niche is 50% at room temperature, the no-sensitization threshold for house dust mites will be reached (Schober, 1989).

Relative humidity in the mite niche is determined by temperature and absolute humidity in the mite niche. Under equilibrium conditions, absolute humidity in the mite niche is the sum of absolute outdoor air humidity and water vapour production by household activities, remaining after ventilation (Tammes and Vos, 1984). During winter, the contribution of absolute outdoor air humidity will be low due to lower outdoor air temperatures in Europe.

This suggests that outdoor air temperature and humidity, heating and ventilation determine the differences in mite numbers in climatically distinct areas in Europe. To test this hypothesis, we defined variables in which these factors are taken into account. Validation of these variables has been done with published information on mite numbers on floors and mattresses in Europe.

METHODS AND MATERIALS

Outdoor temperature and air humidity

Hourly data of simultaneously recorded outdoor temperature and relative air humidity were obtained from European Test Reference Years (TRY), when available. TRY's are given of climatically homogeneous areas in Denmark, United Kingdom, Ireland, The Netherlands, Belgium, France, and Italy (Commission of the European Communities, 1985).

Monthly climatic data of Finland, Poland, and the Mt Ventoux region (France) were obtained from Müller (1983). For Davos, these data were given by the Schweizerische Meteorologie Anstalt in Zürich, Switzerland.

From these data, mean January outdoor air temperature was recorded. Based on outdoor temperature and absolute outdoor air humidity length of heating season and length of mite population growth season were defined.

Mean January outdoor air temperature

The mean January outdoor air temperature was recorded. In the Netherlands and Germany, a relation has been seen between lowering mean January outdoor air temperature and decreasing guanine positive floor dust samples (van Bronswijk and Schober, 1993).

Heating season

In previous studies length of heating season was considered a limiting factor (van Bronswijk, 1981 and 1991). We defined heating season as the number of months in which the mean daily outdoor temperature falls 2.5°C or more below the lower comfort level of indoor temperature, T_{lc} (Hoen and Thijs, 1981).

The lower comfort level of the indoor temperature varies in different countries: in the Netherlands at 18°C, in Denmark at 17°C, in the United Kingdom at 15.5°C, in Italy at 19°C, and in France at 17.5°C (Bourges, 1992; Lyberg, 1987). We set the lower comfort level for Poland at 19°C (as Germany), for Switzerland at 18°C (in between France and Germany), and for Finland at 17°C (as Denmark and Sweden)

Mite population growth season (mite season)

Length of mite population growth season - abbreviated to mite season - was defined as the number of months in which the mean monthly relative humidity in a home textile rises above 50% at room temperature, the hygienic moisture limit for mite sensitization (Schober, 1989). The estimation of length of mite seasons is shown in Figure 1.

Bedroom conditions

Bedroom conditions were considered during the non-occupied period, between 8.00h and 24.00h. During occupation, human heat and sweat will be contributed to the mattress. However, the relative humidity in the mite niche during the non-occupied period can form a limiting factor for mite population growth (van Bronswijk, 1981). Mite population growth will be determined by the combination of length of drying out period and lowness of relative humidity in home textiles during this period (van Bronswijk and Jorde, 1975).

When not occupied, we assumed the bedroom would not be heated above the lower comfort level of a country. The bedroom air temperature was set at the lower comfort level of that country, if the outdoor air temperature was below this level. If the outdoor air temperature was above the lower comfort level, the outdoor air temperature was used (Figure 1).

In this non-occupied period we did not contribute water vapour by household activities to the absolute outdoor air humidity. The contribution of water vapour production by human sweat is negligible within 2-4 hours after the bed has been left (van Bronswijk, 1981).

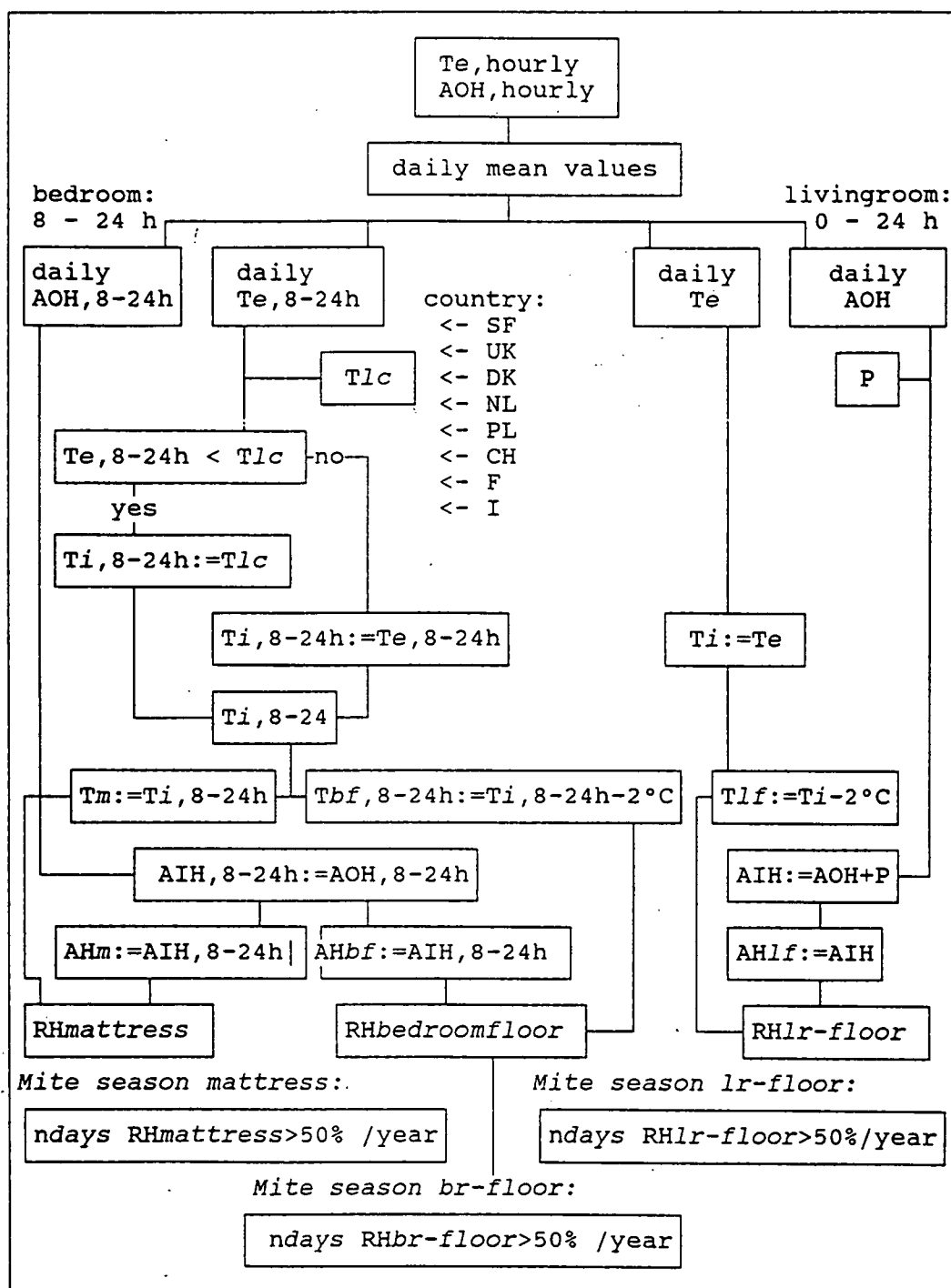


Fig. 1. Flow diagram for the estimation of length of mite season in mattress, bedroom and livingroom floor.

Tlc = lower comfort level of indoor air temperature
 Te = outdoor air temperature
 Ti = indoor air temperature
 Tm = temperature of mattress
 Tbf = temperature of bedroom floor
 Tlf = absolute temperature of livingroom floor
 8 - 24h = non-occupied period in bedroom

P = water vapour production by household activities
 AOH = absolute outdoor air humidity
 AIH = absolute indoor air humidity
 AHm (RHmattress) = absolute (relative) humidity in mattress
 AHbf (RHbr-floor) = absolute (relative) humidity on bedroom floor
 AHlf (RHlr-floor) = absolute (relative) humidity on livingroom floor
 0 - 24h = all day

Table 1. Description of mite (allergen) data extracted from the literature.

Weather station (Country)	Sampling locality (Country)	Textile sampled* (n of samples)	Mites/ Allergen ^x	Data used from the literature
Eskdalemuir (United Kingdom)	Glasgow ^{1 †} (UK)	mattress (n = 65) br-carpet (n = 27)	tot Pyr	mean
Aberporth (United Kingdom)	Cardiff ² (UK)	mattress (n = 50) br-floor (n = 32)	tot Pyr	mean
Kew (United Kingdom)	Birmingham ³ (UK)	mattress (n = 19) br-carpet (n = 5) lr-carpet (n = 5)	tot Pyr	median
Copenhagen (Denmark)	Aarhus ⁴ (DK)	mattress (n = 24) br-floor (n = 24)	D. pter	median
De Bilt (The Netherlands)	Utrecht ⁵ (NL)	mattress (n = 20) br-carpet (n = 14) lr-carpet (n = 16)	tot Pyr	median
Vlissingen (The Netherlands)	Leiden ⁶ (NL)	lr-floor (n = 150)	tot Pyr	mean
Mt Ventoux (France)	Briançon ^{7a} (F)	mattress (n = 115)	Der p I	mean
Nice (France)	Marseille ^{7b} (F)	mattress (n = 126)	Der p I	mean
Milan (Italy)	Milan ^{8a} (I)	mattress (n = 15)	tot Pyr	median
Rome (Italy)	Naples ^{8b} (I)	mattress (n = 6)	tot Pyr	median
Davos (Switzerland)	Davos ⁹ (CH)	lr-floor (n = 4)	tot Pyr	mean
Punkaharju (Finland)	Uukuniemi/ Ilomantsi ¹⁰ (SF)	mattress (n = 7)	tot Pyr	median
Krakow (Poland)	Katowice/Bytom ¹¹ (PL)	mattress (n = 21)	tot Pyr	median

* br-carpet = bedroom carpet ; br-floor = bedroom floor;

lr-carpet = livingroom carpet

; lr-floor = livingroom carpet.

^x tot Pyr = all mites of the family Pyroglyphidae;

D. pter = *Dermatophagoides pteronyssinus*.

† Number after sampling locality relates to numbered paper in reference section.

Length of mite season in mattresses

For mattresses, mean temperature during non-occupation equals mean bedroom air temperature. Absolute humidity in mattresses was equated with absolute bedroom air humidity during non-occupation (Figure 1).

Length of mite season on bedroom floors

For bedroom floor temperature we subtracted 2°C of bedroom air temperature (Werkgroep Binnenklimaat en Energieverbruik, 1973). Like in mattresses, absolute bedroom floor humidities were equated with absolute bedroom air humidities (Figure 1).

Living room conditions

We assumed that in all European countries a comfortable living room air temperature of 21°C will be maintained (Werkgroep Binnenklimaat en Energieverbruik, 1973). In this preliminary model we did not take any night-reduction of heating into account. For absolute indoor air humidity in the

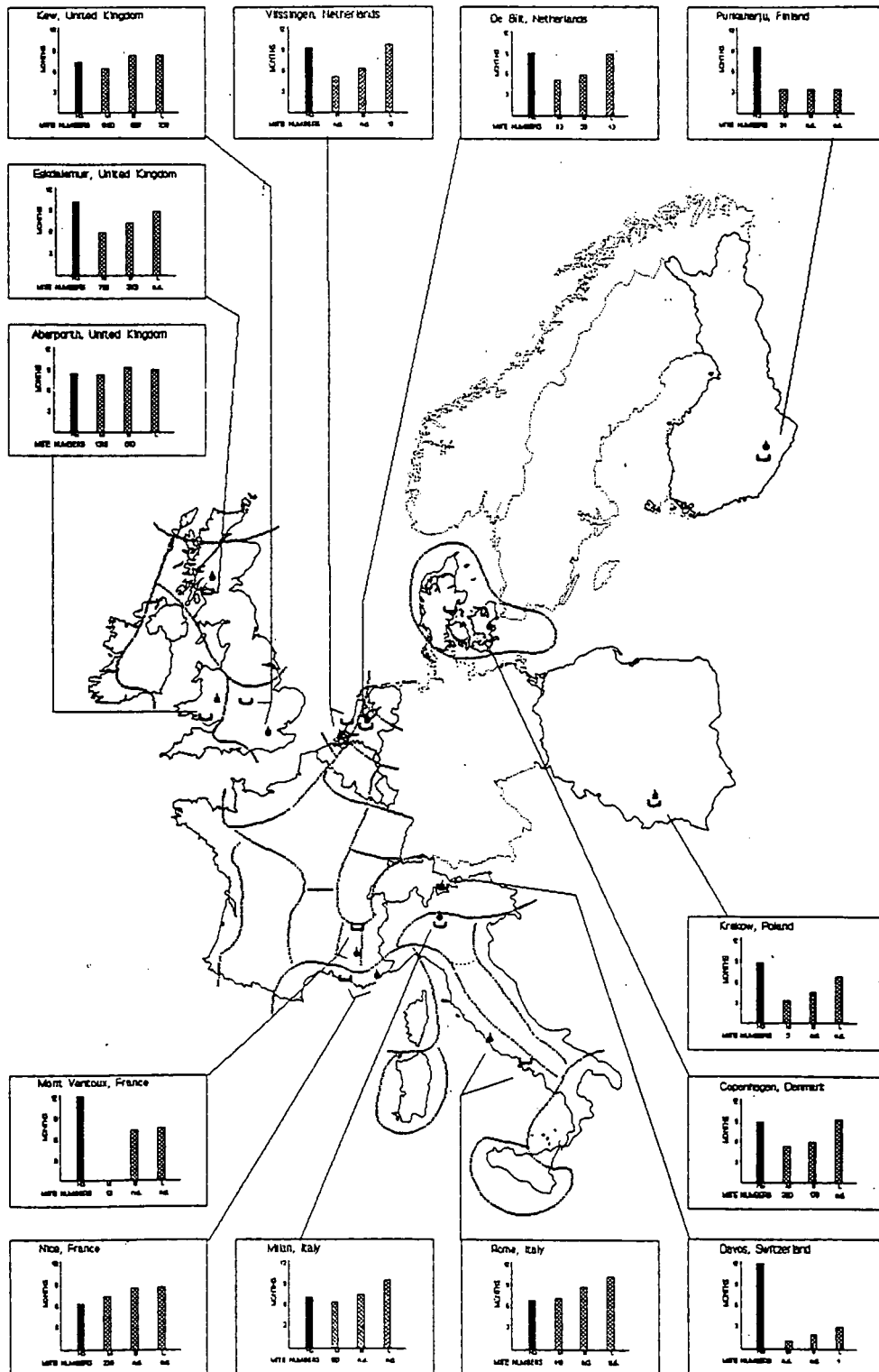


Figure 2. Map of weather stations and sampling localities. \triangleright = weather station; U = sampling locality; --- = climatic regions; In squares: vertical axis: number of months; horizontal axis: HS = length of heating season; M, B, L = length of mite season in mattresses, on bedroom floors, and on livingroom floors respectively; under horizontal axis; Mite numbers = number of pyroglyphid mites, mentioned or calculated, in corresponding home textiles per gram dust, n.d. = not done.

living room, we added the maximal water vapour production by household activities to the absolute outdoor air humidity (Tammes and Vos, 1984).

Length of mite season on living room floors

Temperature on living room floors was set 2°C below the living room air temperature at 19°C (Werkgroep Binnenklimaat en Energieverbruik, 1973). Absolute living room floor humidity was equated with absolute living room air humidity (Figure 1).

Ventilation

Ventilation can diminish the contribution of water vapour production by household activities (Tammes and Vos, 1984). Therefore, minimal required ventilation rates to keep the relative humidity in the mite niche below 50% in different European countries have been collected.

House dust mite data

The usage of mean January outdoor air temperature and our definitions of length of heating season and mite population growth season to predict mite abundance were validated by published information on numbers of house dust mites on floors and mattresses. These data were collected with the aid of Index Medicus (1966 up to March 1993) and the collection of the Interuniversity Task Group "Home and Health", The Netherlands. Quantitative data of Pyroglyphid mites or the major allergen *Der p I* were recorded.

When available, median values of mite or allergen densities were preferred to mean values (Table 1). For comparative purposes both median and mean values were divided by the no-sensitization threshold for house dust mites to obtain the so-called exposure rate. To compare quantitative data on allergen *Der p I* with those on Pyroglyphid mites, the allergen load was divided by a factor of 20 for mattresses and a factor of 200 for floors, being the ratios between the no-sensitization thresholds for allergens and for mites.

Statistical analyses

For mattresses, bedroom floors, living room floors and floors (bedroom and living room floors) the Spearman rank correlation test was used to test relations between mean January outdoor air temperature and exposure rate; between length of heating season and exposure rate; between length of mite season and exposure rate; between mean January outdoor air temperature and length of mite season; and between length of heating season and length of mite season. The correlation between mean January outdoor air temperature and length of heating season was tested independent of home textile (Siegel, 1956). The confidence level has been set at 5%.

Analyses of differences in length of mite season between mattresses and bedroom floors; mattresses and living room floors; mattresses and floors; and bedroom and living room floors were performed using the Mann-Whitney U test (Siegel, 1956). Only house dust mite data with an exposure rate ≤ 1 were taken into account. The confidence level has been set at 5%.

RESULTS

House dust mite data

In the 13 areas reported, numbers of Pyroglyphid mites⁸ were given, or could be calculated out of the number of all mites^{1-3,5,6,11} or consisted of combined counts of *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae* and *Euroglyphus maynei*^{9,10}. In Denmark⁴ numbers of *Dermatophagoides pteronyssinus* are given. In France⁷ allergen *Der p I* was noted (Table 1).

The period and method of sampling, and extraction technique were not uniform in different areas and no exact description of floor covering, textile or non-textile, was given.

In Denmark, the Netherlands and the United Kingdom, more house dust mites per gram dust were found in mattresses than on floors; and more on bedroom floors than on living room floors

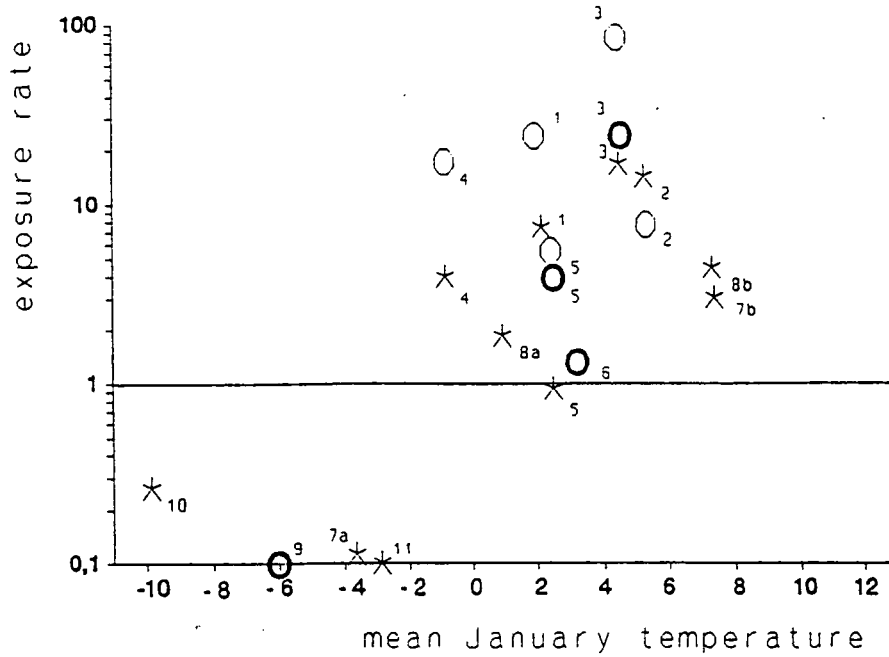


Figure 3a. Mean January outdoor air temperature and exposure rate in different home textiles.

Line indicates no-sensitization threshold for house dust mites. Mean January temperature = mean January outdoor air temperature. * = mattresses; O = bedroom floors; O = livingroom floors. Ciphers refer to numbers of sampling localities in Table 1.

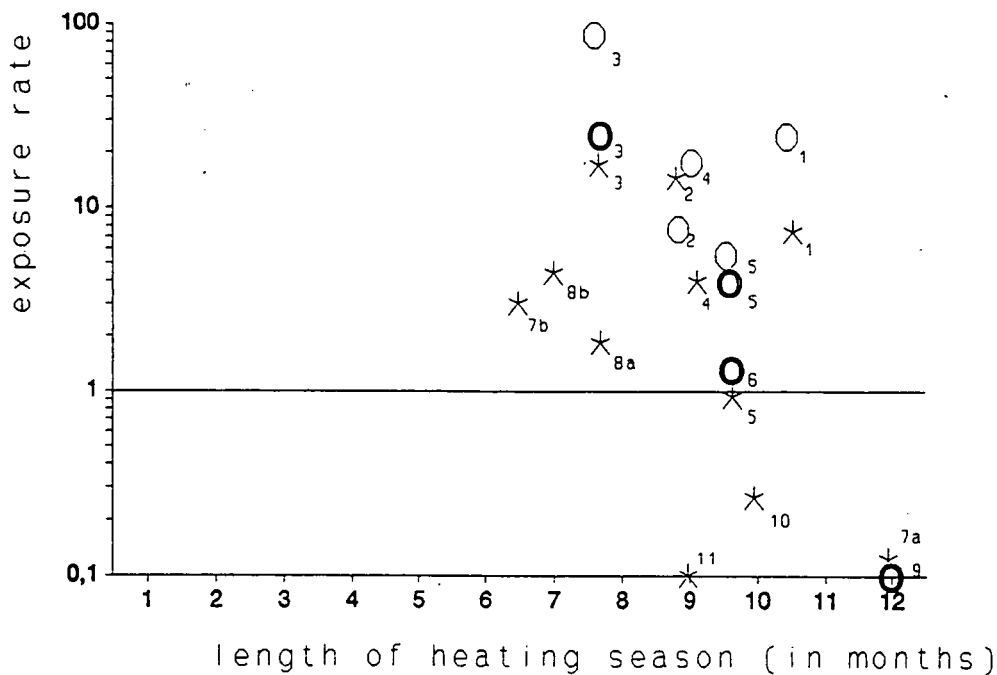


Figure 3b. Length of heating season (in months) and exposure rate in different home textiles.

Line indicates no-sensitization threshold for house dust mites. * = mattresses; O = bedroom floors; O = livingroom floors. Ciphers refer to numbers of sampling localities in Table 1.

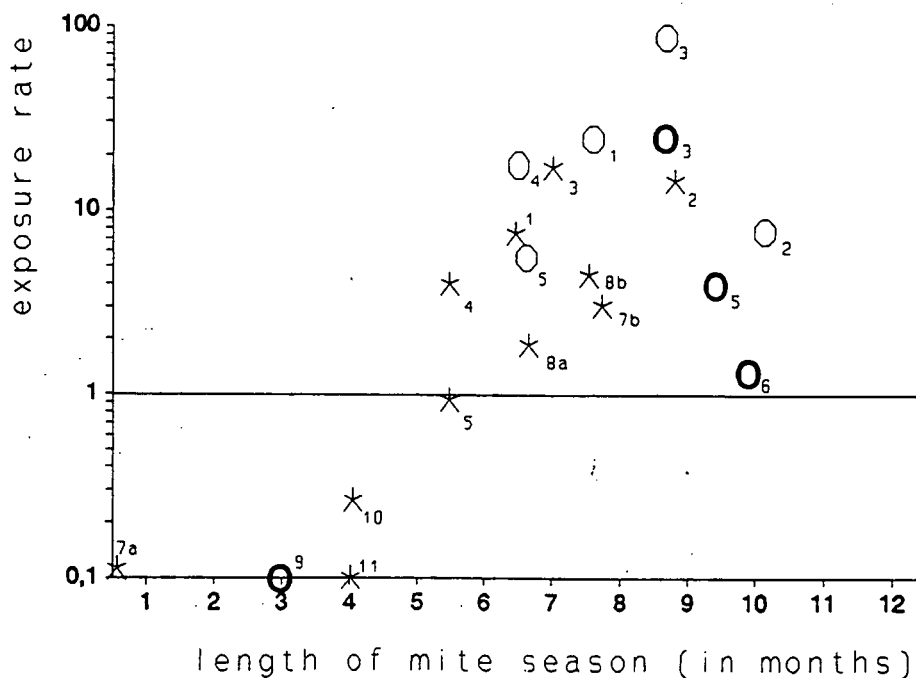


Figure 3c. Length of mite season (in months) and exposure rate in different home textiles.

Line indicates no-sensitization threshold for house dust mites. * = mattresses; O = bedroom floors; O = livingroom floors. Ciphers refer to numbers of sampling localities in Table 1.

(Figure 2). Of Finland, France, Switzerland, Italy and Poland no combined data about house dust mite numbers in different home textiles were mentioned.

In 8 of the 13, areas mite or allergen densities in mattresses and on floors exceeded the no-sensitization threshold several times. The exceptions were mite densities found in mattresses from De Bilt⁵, Briançon^{7a}, East-Finland¹⁰ and Katowice¹¹, and on living room floors from Davos⁹ (Figure 3).

Mean January outdoor air temperature

A significant correlation between mean January outdoor air temperature and exposure rate in mattresses was seen (Spearman rank correlation test, $p < 0.05$). For floors no significant correlation was seen (Figure 3a).

Heating season

In all areas heating season was longer than 6 months (Figure 3b). In those areas where mite numbers did not exceed the no-sensitization threshold for house dust mites, the heating season lasted 9 months or more^{5,7a,9-11}. However, the reverse relation was not seen. Spearman rank correlation test revealed no significant correlations between length of heating season and exposure rate.

Mite season

The correlation between length of mite season and exposure rate in mattresses was significant ($p < 0.05$). No significant correlations between length of mite season and floors, bedroom and living room floors separately or combined, were demonstrated by Spearman rank correlation test.

Mite densities above the no-sensitization threshold for house dust mites were found in mattresses when the defined mite season was longer than 5 months; on bedroom floors longer than 6.5 months; and on living room floors longer than 8.5 months (Figure 3c). Using a Mann-Whitney U test the mite season in mattresses was significantly shorter than on living room floors ($p < 0.05$).

Relations between the climatic variables

Mean January outdoor air temperature was significantly correlated with length of mite season in all home textiles, apart from living room floors. An inverse relation between length of heating season and length of mite season was seen. This relation was significant in mattresses only. The inverse relation between mean January outdoor air temperature and length of heating season was significantly correlated (Spearman rank correlation test, $p < 0.05$).

Ventilation

Data about ventilation rates in dwellings required to keep indoor air humidity below the hygienic moisture limit for mites for a considerable time in a certain outdoor climate have been obtained from Denmark and the Netherlands, only.

In Denmark, mean daily relative indoor air humidity will theoretically be below 50% for 7 months, November until May, if the minimum ventilation rate is 1.0 ach (Air Changes per Hour) during those months (Korsgaard, 1990; Schober, 1991).

Schober (1991) extrapolated from the Danish data the minimal required ventilation rate in The Netherlands. In Dutch dwellings the minimal required ventilation rate should be 1.0 ach during the months November until April and should preferably be increased to 1.5 ach in May and October.

DISCUSSION

In those climatic areas where mite numbers did not exceed the no-sensitization threshold for house dust mites, the heating season lasted 9 months or more^{5,7a,9-11}. However, no correlation between heating season and exposure rate was demonstrated in any of the home textiles.

In 1981, van Bronswijk found almost no house dust mites in Scandinavia, when the heating season was longer than 9 months. However, in the cool marine climate of Northern Scandinavia the outdoor temperature will stay below 6.1°C during 6 to 9 months (Miller, 1963). During these months the contribution of absolute outdoor air humidity to indoor air humidity will not be sufficient to exceed the hygienic moisture limit for mite sensitization most of the time, if no water vapour is added by household activities.

The dryness of the heating season rather than the length of this period is important (van Bronswijk and Jorde, 1975). Therefore the combined data of outdoor air temperature and absolute humidity should be used. These data are directly or indirectly incorporated in the climatic variables mean January outdoor air temperature and length of mite season.

January is, in all tested climatic areas, the coldest month¹⁻¹¹. During this month the contribution of absolute outdoor air humidity to the relative humidity in the mite niche might be too low to exceed the hygienic moisture limit for mite sensitization.

In the definition of length of mite season, outdoor air temperatures and absolute humidities during a year are taken into account. Not only the dryness but also the length of the drying out period is described by this climatic variable.

Mean January outdoor air temperature and length of mite season showed significant correlations with the exposure rate in mattresses. These climatic variables seem useful tools to predict overall mite abundance in mattresses in a climatic area.

On floors no significant correlations were seen between mean January outdoor air temperature and exposure rate; nor between length of mite season and exposure rate. This can be caused by several factors. Sampling conditions were not uniform and no data about floor covering, textile or non-textile, and on which floor level the bedroom is situated, were recorded.

However, the most important factor for the defined length of mite season on floors is the estimated floor temperature. In all countries floor temperature was set 2°C below indoor air temperature. In this way differences in soil and construction were not taken into account.

In our model, bedroom conditions were defined during non-occupation only. This may have consequences especially for mattresses and the predicted length of mite season in mattresses may be predicted too short, with no contribution of sweat during occupation taken into account. However, length of mite season seems shorter in mattresses than on floors. This might explain why in climatic areas with borderline climatic conditions for the survival of house dust mites, the mattresses may be a hazard to atopic patients, while the floors are not (van Bronswijk and Schober, 1993).

The length of mite season can be reduced by effective ventilation. Minimal required ventilation rates to keep relative humidity in the mite niche below 50% have been obtained from Denmark and the Netherlands only (Korsgaard, 1990; Schober, 1991). To give suitable advice for allergen avoidance measures in other climatic areas minimal required ventilation rates have to be known.

In this study we found that the mean January outdoor air temperature and length of mite season can predict the overall mite abundance in mattresses in climatically distinct areas in Europe. For floors, the influence of outdoor air temperature and absolute humidity should be examined in combination with soil and constructional factors.

To predict the mite burden in an individual dwelling, measurement of the absolute indoor air humidity and room temperature is needed, where there is an extensive variability in mite numbers between dwellings in a climatic area^{2-5,7,9-11}.

Acknowledgements

The authors are grateful to the GuT, Gemeinschaft umwelt-freundlicher Teppichboden E.V., Aachen, Germany, for financial support; and to dr. F.M. Kniest, Allergopharma, Reinbek, Germany for his unpublished data about the abundance of house dust mites in home textiles in Utrecht and environs, The Netherlands.

References

- Colloff, M.J. (1987). Mites from house dust in Glasgow. *Med. Vet. Entomol.* 1:163-168.
- Rao, V.R.M., Dean, B.V., Seaton, A., and Williams, D.A. (1975). A comparison of mite populations in mattress dust from hospital and from private houses in Cardiff, Wales. *Clin. Allergy* 5:209-215.
- Blythe, M.E., Williams, J.D., and Morrison Smith, J. (1974). Distribution of pyroglyphid mites in Birmingham with particular reference to *Euroglyphus maynei*. *Clin. Allergy* 4:25-33.
- Harving, H., Korsgaard, J., Dahl, R., Beck, H.-I., and Bjerring, P. (1990). House dust mites and atopic dermatitis. A case-control study on the significance of house dust mites as etiologic allergens in atopic dermatitis. *Ann. Allergy* 65: 25-31.
- Kniest, F.M. (1990). Thesis research: non-published data. Thesis: The management of dust allergens. Interuniversity Task Group "Home and Health", Utrecht State University and Eindhoven University of Technology, the Netherlands.
- Spieksma, F.Th.M., and Spieksma-Boezeman, M.I.A. (1967). The mite fauna of house dust with particular reference to the house-dust mite *Dermatophagoides pteronyssinus* (Trouessart, 1897) (Psoroptidae: Sarcoptiformes). *Acarologia* 9(1):226-241.
- Charpin, D., Birnbaum, J., Haddi, E., Genard, G., Lanteaume, A., Toumi, M., Faraj, F., van der Brempt, X., and Vervloet, D. (1991). Altitude and allergy to house-dust mites. A paradigm of the influence of environmental exposure on allergic sensitization. *Am. Rev. Respir. Dis.* 143:983-986.
[7a = Brian'on], [7b = Marseille]
- Blythe, M.E. (1976). Some aspects of the ecological study of the house dust mites. *Brit. J. Dis. Chest* 70:3-31.
[8a = Milan], [8b = Naples]
- Spieksma, F.Th.M., Zuidema, P., Leupen, M.J. (1971). High altitude and house-dust mites. *Brit. Med. J.* 1:82-84.
- Stenius, B., and Cunningham, A.M. (1972). House dust mites and respiratory allergy: a qualitative survey of species occurring in Finnish house dust. *Scand. J. Resp. Dis.* 53:338-348.
- Hork, B. (1987). Preliminary study on the concentration and species composition of bacteria, fungi and mites in samples of house dust from Silesia (Poland). *Allergol. et Immunopathol.* 15(3):161-166.
- Bourges, B. (1992). Temperature and degree-days. p101-112. In: Climatic data handbook for Europe. Climatic data for the design of solar energy systems. Bourges, B., ed.
- Bronswijk, J.E.M.H. van, and Jorde, W. (1975). Mites and allergenic activity in house-dust on Heligoland. *Acta Allergologica* 30:209-215.
- Bronswijk, J.E.M.H. van. (1981). House dust biology for allergists, acarologists and mycologists. NIB, Zeist, The Netherlands.
- Bronswijk, J.E.M.H. van. (1991). Ziek van je huis. Intree-rede Rijksuniversiteit Utrecht, Utrecht, the Netherlands.
- Bronswijk, J.E.M.H. van, and Schober, G. (1993). Geoklimatische Verteilung von Innenraumallergenen. p69-84. In: Münchengladbacher Allergie-Seminar Band 5. Innenraumallergene. 14. Münchengladbacher Allergie-Seminar 22. und 23. November 1991. Dustri-Verlag Dr. Karl Feistle M'Gnchen-Deisenhofen. Jorde, W., and Schata, M., eds.
- Commission of the European Communities, Directorate General XII for Science, Research and Development (1985). Test Reference Years TRY. Weather data sets for computer simulations of solar energy systems and energy consumption in buildings. EUR 9765. 1985 ECSC, EEC, EAEC Brussels and Luxemburg.

- Hoen, P.J.J., and Thijs, R.V.L.M. (1981).** Verbeterde graaddagenmethode. Rapportnummer: 80-16-K. Eindhoven, The Netherlands. Herziene druk juni 1981.
- Korsgaard, J. (1990).** Mechanical ventilation and house dust mites: a controlled investigation. p87-89. In: Dust mite allergens and asthma. Report of the Second International Workshop. Minster Lovell, Oxfordshire, England. September 19-21, 1990. The UCB Institute of Allergy, Brussels, Belgium.
- Lyberg, M.D. (1987).** Appendix H. Analysis Techniques (E); and appendix I. Reference values (E). In: Source book for energy auditors. IEA Energy Conservation, April 1987. Lyberg, M.D., ed. ISBN 91-540-4763-3.
- Miller, A.A. (1963).** V. The classification of climates. p78-100. In: Climatology. Methuen & co. Ltd London, and Dutton, E.P. & co. Inc. New York.
- MGller, M.J. (1983).** Handbuch Ausgewhlter Klimastationen der Erde. 3.ergnzte und verbesserte Auflage. Richter, G., ed.
- Platts-Mills, T.A.E., de Weck, A.L. (1989).** Dust mite allergens and asthma - A worldwide problem. *J. Allergy Clin. Immunol.* 83:416-427.
- Schober, G. (1989).** Absolute indoor air humidity and the abundance of allergen producing house dust mites and fungi in The Netherlands. p394-397. In: Elsevier Science Publishers. *Proceedings: Present and future of indoor air quality.* Bieva, C.J., Courtois, Y., Govaerts, M., eds.
- Schober, G. (1991).** Prevention: humidity relationships. p149-154. In: Thesis: Control of allergic mites and fungi in house dust.
- Siegel, S. (1956).** The Mann-Whitney *U* test. p116-127 and The Spearman rank correlation coefficient: r_s . p202-213. In: Nonparametric statistics for the behavioral sciences. McGraw-Hill, New York.
- Tammes, E., and Vos, B.H. (1984).** Vochtproduktie en vochtigheid binnen. p52-57. In: Warmte- en vochttransport in bouwconstructies. Tweede druk. Kluwer Technische Boeken B.V., Deventer, ed. ISBN 90 201 1710 6.
- Werkgroep Binnenklimaat en Energieverbruik. (1973).** De mens in zijn binnenklimaat. p13-26. In: Binnenklimaat en Energieverbruik. N.V. Nederlandse Gasunie, Groningen.