

ACARI 635

The colonisation of new houses by house dust mites (Acari: Pyroglyphidae)

Wietske A.D. van der Hoeven, Rob de Boer and Jan Bruin

*University of Amsterdam, Department of Pure and Applied Ecology, Section Population Biology,
Amsterdam, Netherlands*

ABSTRACT

van der Hoeven, W.A.D., de Boer, R. and Bruin, J., 1992. The colonisation of new houses by house dust mites (Acari: Pyroglyphidae). *Exp. Appl. Acarol.*, 16: 75–84.

House dust mites, *Dermatophagoides* species (Acari: Pyroglyphidae), produce allergens, known for the provocation of asthma and other allergic reactions. To determine the time needed for complete colonisation of a new house by house dust mites, dust samples were collected from carpets of houses varying from 2 weeks to 2 years in age. In contrast to the expectation, no relation was found between age of the houses on the one hand and average levels of mite-allergens *Der pI* and *Der pII* and mite numbers on the other. However, presence of dogs appeared to be positively related to allergen levels. Furthermore, carpets in bedrooms appeared to contain more allergens than carpets in living-rooms. Finally, the age of the mattress was not related to allergen levels of bedroom floors.

INTRODUCTION

Since the work of Voorhorst et al. (1969), it is generally accepted that house dust mites produce allergens. Their faecal material is highly allergenic (Tovey et al., 1981) and can provoke asthma as well as other allergic reactions when inhaled (Wharton, 1976). *Dermatophagoides pteronyssinus* (Trouessart), *D. farinae* Hughes, both cosmopolitan species (Van Bronswijk and Sinha, 1971), and *D. microceras* Griffiths & Cunnington are known for their allergenic properties (Heymann et al., 1989).

Mite numbers show an annual periodicity, which coincides with the annual humidity cycle in the house (Spieksma and Spieksma-Boezeman, 1967; Platts-

Correspondence to: J. Bruin, University of Amsterdam, Department of Pure and Applied Ecology, Section Population Biology, Kruislaan 302, 1098 SM Amsterdam, Netherlands.

Mills et al., 1987). *Dermatophagoides pteronyssinus*, more susceptible to desiccation stress than *D. farinae*, is the most common species in house dust in Western Europe (Van Bronswijk, 1981). House dust mite populations reach peak levels in late summer (Blythe, 1976) or autumn, when relative humidity is usually highest (Van Bronswijk and Sinha, 1971). In Ohio (USA), for example, the average numbers of live mites per gram dust were (far) more than ten times higher in late summer than in spring (Arlian, 1982). Another study (Platts-Mills et al., 1987), in central Virginia, revealed that the allergen level in autumn was often more than 20 times as high as the level in spring. These authors stated that decomposition of allergens might take several months.

The highest numbers of mites are found in places where dust (e.g. skin scales), the food source for house dust mites, accumulates. Beds, upholstered furniture and carpets are the primary culprits (Arlian, 1989). In contrast, no house dust mites were detected on floors of new houses where people had lived for less than 1 week (Van Bronswijk (1974), in the Netherlands) or for less than 1 month (Miyamoto and Ouchi (1976), in Japan). Arlian (1982) found one home in a study of 26 with no infestation. This house was less than 2 months old and contained new furnishings and carpeting. In another study involving 16 homes, two yielded no mite infestations, which could be explained by relatively new carpets (Arlian et al., 1978). So far, no information is available on the length of time needed for complete colonisation of a new home by house dust mites.

The aim of the present study was to assess the relationship between the occupation time of the house on the one hand and numbers of mites and allergen levels in dust from carpets on the other. In brand new homes with new carpeting, low allergen levels were expected, as a function of low food supply and thus low mite population growth rate. The mite population was expected to increase with increasing occupation time, until carrying capacity was reached.

MATERIALS AND METHODS

Dust samples

Dust samples were collected from carpets in bedrooms and living-rooms in the second half of May 1990. The age of the homes varied from 2 weeks to 2 years. Only rooms with new carpets at the start of occupation were sampled. In this study carpet is defined as wall-to-wall carpet and excludes throw-rugs, area rugs and Persian 'carpets'. A total of 114 rooms in 60 different houses in Dronten (Flevoland, the Netherlands) was sampled. All houses were one-family dwellings and were centrally heated.

Information on various parameters which could possibly influence mite numbers, was obtained by questioning the residents. Questions concerned among others the number of occupants in the house, the number of pets, the

type of carpet material, the age of mattresses, and whether food was consumed in the bedroom.

Samples were taken using a Moulinex® Compact 1250 Vario Electronic vacuum cleaner at 800 W. This vacuum cleaner was equipped with a built-in sampling device in a specially constructed hose. The sample was collected in a glass tube with an inner diameter of 4.3 cm, which was covered at one end with a filter cut out of the densest layer of double layer Moulinex® dust bags.

In order to collect one sample, 2 m² of the carpet were vacuum cleaned for 4 min, i.e. standardised to 2 min per m² as suggested by Platts-Mills and De Weck (1988). After taking one sample, the glass tube with the sample was replaced by a new one. Parts of the vacuum cleaner which had been in contact with the previously collected sample were either replaced or cleaned. All samples were taken by the same person.

The tubes containing the samples were stored, for a maximum of 2 days, in separate plastic bags at 4°C until the samples were weighed. Part of each sample was stored at -20°C until allergen assays were done. The portion destined for mite analysis was preserved in 70% ethanol.

Allergen assays

Measurements of the major allergens *Der pI* and *Der pII* were done at the Department of Allergy of the Central Laboratory of The Netherlands Blood Transfusion Service (CLB). Immunochemical techniques were applied, i.e. two different radio-immuno-assays (RIAs) were used to quantify the respective allergen activity. These methods were described in detail by De Boer (1990). The antibodies of the RIA employed for determination of *Der pI* respond specifically to group I allergens of *D. pteronyssinus*, while the antibodies of the second RIA do not distinguish between group II allergens of *D. pteronyssinus*, *D. farinae* and *D. microceras* (Van der Zee et al., 1988; Van Leeuwen and Aalberse, 1988). Results are expressed per gram house dust as well as per m², following Abbott et al. (1981).

Mite counts

Samples were classified into five groups, according to the age of the house where they had been collected. From each age-class four samples were randomly chosen for determination of mite numbers. The procedure used was adapted from Hart and Fain (1987); instead of saturated NaCl demineralised water was used. When mite numbers were higher than 15, a method of mass transfer was applied according to Colloff (1989). Mites that were alive at the time of sampling could easily be distinguished from dead ones because of their white and plump appearance.

Statistical analysis

The logarithms of the *Der pI* and *Der pII* values exhibited an approximately normal distribution around their group means. Student's *t*-test, one-way analysis of variance (ANOVA) and Pearson's product-moment correlation test were applied on log-transformed data. In other cases nonparametric statistical techniques were used. All tests (except for the correlation tests) were two-tailed.

The 15 samples taken in rooms that had been used for a shorter period of time than the rest of the house, e.g. rooms of newborn babies, were excluded from statistical analyses. Four samples were excluded because both allergen levels were below the detection range of the test. In cases where one of the allergen levels was outside the detection range, the results of the other allergen were included. In two samples the *Der pI* level was below and in nine samples the *Der pII* level was above the test range. In 18 cases the level of *Der pII* was below the test range, whereas the *Der pII* level was never too high to assess. Whether or not these exclusions have any implications is discussed when appropriate.

RESULTS

No relationship could be shown between allergen levels (both per gram dust and per m²) in the carpet samples and the age of the house (ANOVA, *Der pI*/g, $P=0.99$; *Der pII*/g, $P=0.45$; *Der pI*/m², $P=0.63$; *Der pII*/m², $P=0.25$). Likewise, no relationship was found between quantity of dust and age of the house (ANOVA, $P=0.13$) (Fig. 1). Samples (partially) excluded were equally distributed over the age classes. For instance, a sample taken in a 2-week-old house was excluded for *Der pI* because of a too high level for quantification. The level of *Der pII* (5.5 µg/gram dust) in this sample was second highest of all samples.

When households with no pets (i.e. no cat or dog) were compared to house-

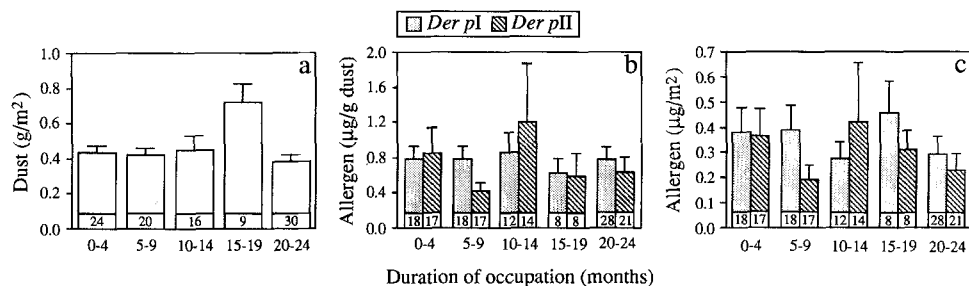


Fig. 1. Average dust quantity per m² (a) and average level of the allergens *Der pI* and *Der pII* per gram dust (b) and per m² (c) in relation to the occupation period of the house (mean + s.e.). Numbers at the foot of each bar represent sample sizes.

holds with a cat only, no significant difference could be shown in dust quantities (t -test, $P=0.22$). However, in households with a dog, dust quantities were higher than in those with no pets (t -test, $P<0.01$) (Fig. 2a). Data concerning the three samples from households having both a cat and a dog were excluded from this analysis.

Carpets in households with a dog contained higher levels of allergens than those in petless households (t -test, *Der pI*/g and *Der pII*/m², $P<0.01$; *Der pI*/m², $P<0.001$). The difference for *Der pII* per gram dust was not significant (t -test, $P=0.08$) (Fig. 2b and c). The factor 'dog' was equally represented in samples that were (partially) excluded from the statistical analysis and those that were statistically processed.

Data collected in households having both a cat and a dog, or a cat only were excluded from this analysis because of insufficient sample sizes.

Average dust quantity and allergen levels were not significantly different between single and double bedrooms (t -test, $P>0.30$). However, carpets in bedrooms – single and double bedrooms together – contained more dust and allergens than carpets in living-rooms (t -test, dust/m² and *Der pI*/m², $P<0.01$; *Der pI* and *Der pII*/g, $P<0.05$; *Der pII*/m², $P<0.001$) (Fig. 3).

To see if the number of occupants had any influence on dust or allergen

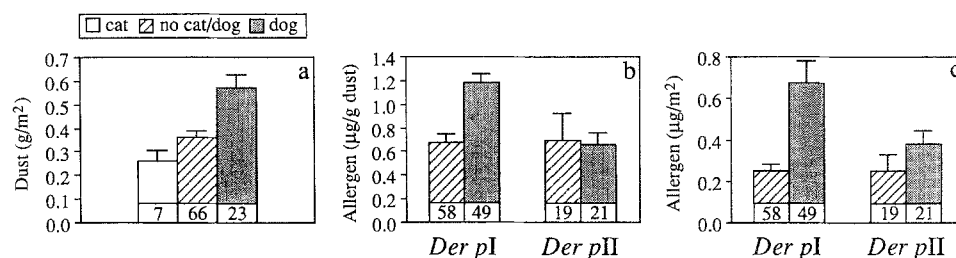


Fig. 2. Average dust quantity per m² in absence or presence of cat or dog (a). Average level of the allergens *Der pI* and *Der pII* per gram dust (b) and per m² (c) in households without a cat or a dog and those with a dog present (mean + s.e.). Numbers at the foot of each bar represent sample sizes.

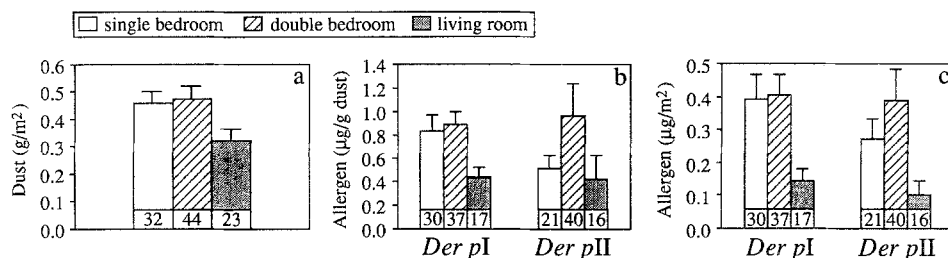


Fig. 3. Average dust quantity per m² (a) and average level of the allergens *Der pI* and *Der pII* per gram dust (b) and per m² (c) in single and double bedrooms and in living-rooms (mean + s.e.). Numbers at the foot of each bar represent sample sizes.

quantity, households from which the living-room had been sampled were arbitrarily divided into classes: 'small', with one or two members and 'large', with three, four or five members. The results show that carpets in the larger households contain more dust and allergens than those in smaller households (Fig. 4). These differences are, however, not statistically significant, except for *Der pI* per m² (*t*-test, $P < 0.05$; *Der pI*/g, $P = 0.42$; *Der pII*/g, $P = 0.47$; *Der pII*/m², $P = 0.06$). The factor 'type of room' (i.e. bedroom or living-room) was equally represented in 'excluded' and statistically processed samples.

Dust quantity nor allergen levels were correlated with frequency of vacuum cleaning. However, living-rooms were more often vacuumed per week than bedrooms (mean $\pm$ s.e.; 2.3 ± 0.30 vs. 1.8 ± 0.17 ; Mann-Whitney *U* test, $P < 0.05$). No significant differences were found between the vacuuming frequency of single and double bedrooms. The frequency of vacuum cleaning is higher in households without a dog than in those with a dog (2.1 ± 0.19 vs. 1.4 ± 0.19 ; Mann-Whitney *U* test, $P < 0.05$). When just considering bedrooms the same holds, i.e. the frequency is higher when there is no dog in the household (2.0 ± 0.23 vs. 1.4 ± 0.19 ; Mann-Whitney *U* test, $P < 0.05$).

The allergens *Der pI* and *Der pII* per gram dust were correlated (Pearson's product-moment correlation test, $r = 0.67$, $P < 0.0001$). The allergen levels per gram dust were independent of the dust quantity per m² (Pearson, *Der pI*, $r = 0.005$, $P = 0.97$; *Der pII*, $r = 0.19$, $P = 0.10$). Correlations between dust quantity per m² and allergens per gram dust on the one hand and allergens per m² on the other hand were expected to occur, since allergens per m² are calculated by multiplying dust quantity per m² by allergens per gram dust. However, the correlation between the allergens per gram dust and those per m² was stronger (Pearson, *Der pI*, $r = 0.83$, $P < 0.0001$; *Der pII*, $r = 0.85$, $P < 0.0001$) than the correlation between dust per m² and allergens per m² (Pearson, *Der pI*, $r = 0.56$, $P < 0.0001$; *Der pII*, $r = 0.68$, $P < 0.0001$).

The variance between rooms of the same house contributes significantly less to the total variance than the variance between the houses. This holds for

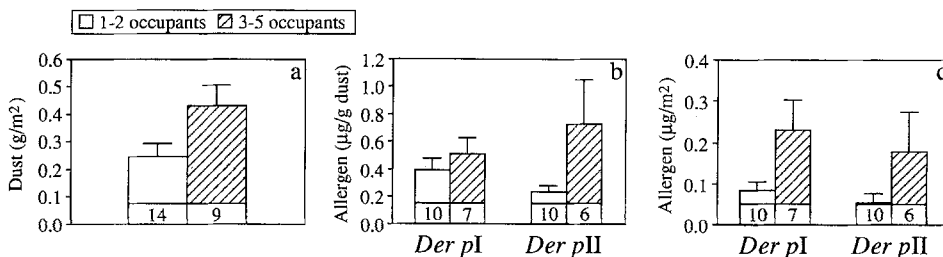


Fig. 4. Average dust quantity per m² (a) and average level of the allergens *Der pI* and *Der pII* per gram dust (b) and per m² (c) in living-rooms in relation to the number of occupants in the house (mean $\pm$ s.e.). Numbers at the foot of each bar represent sample sizes.

the dust quantity (ANOVA, $P < 0.0001$) as well as for the allergens, both per gram dust and per m^2 (ANOVA, *Der pI* per g and per m^2 , $P < 0.001$; *Der pII*/g, $P < 0.05$, *Der pII*/ m^2 , $P < 0.01$).

Age of the occupants of a bedroom, age of the mattress and food consumption in the bedroom had no significant effect on dust quantity or allergen levels.

Analysis of the mite fauna in the 20 selected dust samples showed that two samples were free of mites. Live mites were very rare; three samples contained one live mite each and one sample contained five live mites. The most abundant species was *D. pteronyssinus* (7.4 ± 1.7 ; mean per 0.1 g dust $\pm$ s.e.). *Euroglyphus maynei*, *D. farinae/microceras* and Cheyletidae were also found in considerable numbers, as well as one or a few representatives of the taxa Tarsonemidae, Acaridae, Glycyphagidae, Oribatidae, Tydeidae and Mesostigmata.

Statistical analysis of the results revealed no relationship between age of the house and either the number of intact Pyroglyphidae (1.5 ± 0.72 ; Kruskal-Wallis one-way ANOVA, $P = 0.43$) or the total number of Pyroglyphidae (8.2 ± 2.5 ; Kruskal-Wallis, $P = 0.44$). However, correlations were found between *Der pI* per gram dust and both the number of *D. pteronyssinus* and the total number of Pyroglyphidae (Spearman's rank correlation test, *D. pteronyssinus*, $r = 0.77$, $P < 0.001$; Pyroglyphidae, $r = 0.69$, $P < 0.01$). Furthermore, *Der pII* per gram dust was correlated with both the number of specimens of *Dermatophagoides* spp. and the total number of Pyroglyphidae (Spearman, *Dermatophagoides* spp., $r = 0.57$, $P < 0.05$; Pyroglyphidae, $r = 0.57$, $P < 0.05$).

DISCUSSION

In contrast with our hypothesis, allergen levels and mite numbers in dust samples from carpets were not related to the occupation time of the houses (Fig. 1). A sample taken in a bedroom of a 2-week-old house contained a *Der pI* level above the test range. A possible explanation for the phenomenon that very new houses sometimes contain very high allergen levels is that mites and allergens are mainly introduced, for example, in upholstered furniture or blankets. Introduction of allergens and mites with blankets is not unlikely since Sesay and Dobson (1972) found blankets to contain even higher mite numbers than mattresses. Another possibility is that new carpets are not always free of mites and allergens. If this is true it implies the availability of food, so either food already accumulates in the factory or the material of the carpet serves as a food source. The latter is, however, not supported by the findings of De Boer (1990), who studied the development of mite populations in cleaned carpets. Moreover, it seems very unlikely that mite populations can build up to peak levels in as little as 2 weeks.

Also striking was the detection of very low allergen levels in some 'older'

homes (i.e., almost 2 years old). We do not know why this is so, but a better understanding of the underlying factors may provide clues for the development of future preventative strategies.

The presence of a dog in households is related to a higher dust quantity as well as higher allergen levels (Fig. 2). Of course, this does not necessarily prove that the dog is the cause of these differences. Other factors may be involved. In this connection it is of interest that the vacuuming frequency is lower in households having a dog than in those without a dog. However, a dog, like human beings, produces skin scales and human skin scales are known to be a good food source for house dust mites (Spieksma and Spieksma-Boezeman, 1967).

Arlian (1982) and Hart and Whitehead (1990) found no correlations between presence or absence of pets and the abundance of mites. However, it is not clear if they considered the influence of cats and dogs separately. For example, our data suggest that cats are possibly associated with an opposite effect on the dust quantity compared to that of dogs (Fig. 2a). Perhaps cats and dogs affect mite population size differently. Unfortunately, in the present study the group of households with a cat only was very small (seven), therefore a comparison of allergen levels in households with either a cat or a dog could not be made.

In bedroom carpets dust quantity and allergen levels were higher than in living-room carpets (Fig. 3). The allergen level data are in accordance with the findings of Blythe (1976) that living-room carpets usually contain fewer mites than those in bedrooms. Blythe assumed that this difference was due to different cleaning routines or the scattering of mites from bedding. Different cleaning routines are also a possible explanation in our study, since living-rooms were indeed more often vacuumed than bedrooms, although the vacuuming frequency was not found to be correlated with the dust quantity or allergen levels. Mulla et al. (1975) concluded that there is a tendency for heavier infestations to occur in bedrooms with more occupants (up to four). This was not confirmed in our study, but only bedrooms with up to two persons were sampled.

Considering the living-rooms no significant relationship was found between household size and dust quantity or the allergens, except for *Der pI* per m². Larger households were associated with higher *Der pI* levels per m² than smaller households (Fig. 4). This is in accordance with the findings of Arlian et al. (1978), who showed that average mite infestations were proportional to the number of members in the household. This follows because larger households are likely to produce more food for house dust mites (skin scales and human food) and higher humidity (exhalation vapour, cooking fumes, wet laundry etc.). Moreover, most larger households have one or more small children which means an overall higher usage of the house in terms of space and time.

The degree to which any single factor contributes to mite population growth in new houses is still not clear. The next phase of our research will address some of these single factors in more detail.

ACKNOWLEDGMENTS

The first author is grateful to Rob Aalberse, head of the Department of Allergy of the CLB, Jolanda van Leeuwen, Ed Nieuwenhuys and the people working in the RAST laboratory for help with allergen assays. In the Department of Pure and Applied Ecology thanks go to Rob Lingeman, for statistical advice, Arne Janssen for advice with the statistical computer program, Hans Bolland for identification of some mite species and Paul van Rijn for helping to install computer programs. Finally, thanks go to the inhabitants of the sampled houses, for allowing me to take the samples.

This investigation was supported by the Dutch Asthma Foundation.

REFERENCES

- Abbott, J., Cameron, J. and Taylor, B., 1981. House dust mites counts and different types of mattresses, sheep skins and carpets and a comparison of brushing and vacuuming collection methods. *Allergy*, 11: 589–595.
- Arlian, L.G., 1982. The prevalence of house dust mites, *Dermatophagoides* spp., and associated environmental conditions in homes in Ohio. *J. Allergy Clin. Immunol.*, 69: 527–532.
- Arlian, L.G., 1989. Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. *Immunol. Allergy Clin. N. Am.*, 9: 339–356.
- Arlian, L.G., Brandt, R.L. and Bernstein, R., 1978. Occurrence of house dust mites, *Dermatophagoides* spp. (Acari: Pyroglyphidae) during the heating season. *J. Med. Entomol.*, 15: 35–42.
- Blythe, M.E., 1976. Some aspects of the ecological study of the house dust mite. *Br. J. Dis. Chest*, 70: 3–31.
- Colloff, M.J., 1989. A new and rapid method of making permanent preparations of large numbers of house-dust mites for light microscopy. *Exp. Appl. Acarol.*, 7: 323–326.
- de Boer, R., 1990. The control of house dust mite allergens in rugs. *J. Allergy Clin. Immunol.*, 86: 808–814.
- Hart, B.J. and Fain, A., 1987. A new technique for isolation of mites exploiting the difference between ethanol and saturated NaCl: qualitative and quantitative studies. *Acarologia*, 28: 251–254.
- Hart, B.J. and Whitehead, L., 1990. Ecology of house dust mites in Oxfordshire. *Clin. Exp. Allergy*, 20: 203–209.
- Heyman, W.H., Chapman, M.D., Aalberse, R.C., Fox, J.W. and Platts-Mills, T.A.E., 1989. Antigenic and structural analysis of group II allergens (*Der fII* and *Der pII*) from house dust mites (*Dermatophagoides* species). *J. Clin. Immunol.*, 83: 1055–1067.

- Miyamoto, J. and Ouchi, T., 1976. Ecological studies of house dust mites. Seasonal changes in mite populations in Japan. *Jpn. J. Sanit. Zool.*, 27: 251–259.
- Mulla, M.S., Harkrider, J.R., Galant, S.P. and Amin, L., 1975. Some house-dust control measures and abundance of *Dermatophagoides* mites in Southern California (Acari: Pyroglyphidae). *J. Med. Entomol.*, 12: 5–9.
- Platts-Mills, T.A.E. and De Weck, A.L., 1988. Summary report of the meeting. In: A.L. De Weck and A. Todt (Editors), *Mite Allergy – A World Wide Problem*. Report of an international workshop, Bad Kreuznach, 1–2 September 1987. Publ. U.C.B. Institute of Allergy, Brussels, pp. 3–12.
- Platts-Mills, T.A.E., Hayden, M.L., Chapman, M.D. and Wilkins, S.R., 1987. Seasonal variation in dust-mite and grass-pollen allergens in dust from the houses of patients with asthma. *J. Allergy Clin. Immunol.*, 79: 781–791.
- Sesay, H.R. and Dobson, R.M., 1972. Studies on the mite fauna of house dust in Scotland with special reference to that of bedding. *Acarologia*, 14: 384–392.
- 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*, 11: 226–241.
- Tovey, E.R., Chapman, M.D. and Platts-Mills, T.A.E., 1981. Mite faeces are a major source of house dust allergens. *Nature*, 289: 592–593.
- van Bronswijk, J.E.M.H., 1974. Colonisation and its prevention on house floors and in mattresses with *Dermatophagoides pteronyssinus* (Acari: Sarcoptiformes) in a center for asthmatic children. *Entomol. Exp. Appl.*, 17: 199–203.
- van Bronswijk, J.E.M.H., 1981. *House Dust Biology for Allergists, Acarologists and Mycologists*. NIB Publishers, Zeist, 316 pp.
- van Bronswijk, J.E.M.H. and Sinha, R.N., 1971. Pyroglyphid mites (Acari) and house dust allergy. *J. Allergy*, 47: 31–52.
- van der Zee, J.S., van Zwieten, P., Jansen, H.M. and Aalberse, R.C., 1988. Skin tests and histamine release with P₁-depleted *Dermatophagoides pteronyssinus* body extracts and purified P₁. *J. Allergy Clin. Immunol.*, 81: 884–896.
- van Leeuwen, J. and Aalberse, R., 1988. Antigenen in huisstof. Eindverslag NAF-project, 84.27b, CLB Dept. Allergy, Amsterdam (unpubl.), 51 pp.
- Voorhorst, R., Spieksma, F.Th.M. and Varekamp, H., 1969. *House Dust Atopy and the House Dust Mite Dermatophagoides pteronyssinus*. Stafleu's Scientific Publishing Company, Leiden, 159 pp.
- Wharton, G.W., 1976. House dust mites. *J. Med. Entomol.*, 12: 577–621.