

Seasonal Abundance of Xerophilic Fungi and House-Dust Mites (Acarida: Pyroglyphidae) in Mattress Dust

B.v.d. Lustgraaf*

Laboratory of Minibiology, Institute of Dermatology, State University, Utrecht,
and Department of Botany, Catholic University, Nijmegen, The Netherlands

Summary. Arthropods and xerophilic fungi in dust from 5 mattresses and air-borne fungi were identified and counted every 4 weeks from January 1976 to October 1977.

The arthropod fauna consisted mainly of the pyroglyphid mites *Dermatophagoides pteronyssinus* (58%) and *Euroglyphus maynei* (30%). The fungal flora consisted of *Aspergillus restrictus* (48%), *A. glaucus* (16%), *Wallemia sebi* (3%) and *Penicillium* spp. (25%). Air-borne fungi belonged to the same taxa but in different frequencies, 30, 7, 21 and 27%, respectively. Mattresses differed in quantities of mites and *Penicillium*.

In July 1977, the highest population density of pyroglyphid mites was encountered: 69 specimens/g of dust. In the same month the numbers of *A. restrictus* rose significantly, reaching a maximum of 3.8×10^4 diaspores/g of dust. Most air-borne fungi were isolated in the winter period of 1976/1977. No positive correlation was found between the numbers of air-borne and mattress-dust fungi. The summer of 1976 was exceptionally dry resulting in both a premature decline of the mite populations and a low level of *A. restrictus* diaspores.

The seasonal peaks of *A. restrictus* and pyroglyphid mites correspond and suggest a synergistic cooperation which may result in an increased house-dust allergen production in the environment of asthmatic patients.

Introduction

House-dust mites (Acarida:Pyroglyphidae) are the best-known inhabitants of house dust (Wharton, 1976). *Dermatophagoides pteronyssinus* is the most abundant species in the temperate climate of Western Europe (Bronswijk, 1973).

* Supported by grant no. 230 of the Dutch Asthma Foundation

Present address: Laboratory of Minibiology, Institute of Dermatology, State University, Catharijnesingel 101, Utrecht, The Netherlands

In many countries of Europe, Northern America, Asia and Australia the numbers of house-dust mites show seasonal changes (Voorhorst et al., 1969; Domrov, 1970; Sharp and Haramoto, 1970; Shamiyeh et al., 1972; Bronswijk, 1973; Hughes and Maunsell, 1973; Furumizo, 1973; Oshima, 1975; Mumcuoglu, 1975; Dusbábek, 1975; Popescu and Bănescu, 1975; Miyamoto and Ouchi, 1976; Dar, 1976).

Some of the more xerophilic microorganisms, i.e. fungi belonging to the *Aspergillus restrictus* and *A. glaucus* groups, seem wide-spread in house dust (Lustgraaf, 1977; Lustgraaf and Bronswijk, 1977). Both positive effects (*A. penicilloides*, *Eurotium repens*, *E. amstelodami*) and negative effects (*A. penicilloides*) to house-dust mite populations have been demonstrated in laboratory experiments (Bronswijk and Sinha, 1973; Lustgraaf, 1978). Alterations of house-dust mite populations by xerophilic fungi could be of medical importance as these mites are frequently associated with house-dust allergen(s) (Bronswijk, 1978). But it is not known if xerophilic fungi in house dust show seasonal changes in numbers.

In this study both the numbers of xerophilic fungi and house-dust mites in the dust of 5 mattresses and the numbers of air-borne fungi are followed for 2 subsequent summers. Fluctuations have been considered with respect to synergistic or antagonistic interrelationships.

Material and Methods

From January 2 1976 to September 30 1977 samples were taken every 4 weeks from 5 mattresses located in a cottage at a center for children with educational problems (Institute Bayard) in Groesbeek, The Netherlands. Situation, construction and climate management of the cottage were described earlier (Bronswijk, 1973). Outdoor climatic changes were recorded daily by the Koninklijk Nederlands Meteorologisch Instituut (De Bilt) at Deelen, 30 km from Groesbeek. Indoor relative humidity (Edney hygrometer, Tamson, Zoetermeer) and temperature (mercury thermometer) were recorded weekly to trace significant deviations from outdoor measurements. The cottage was inhabited by 9–12 male children, 13–18 years of age.

The 5 mattresses examined (consecutively numbered 1 to 5) were of polyester foam and had been in use for 17 years. Dust from their upper surfaces was sampled using a vacuum cleaner (Hoover 2907A) with heat-sterilized disposable paper bags. This procedure yielded an average of 0.54 g dust per mattress and did not affect the quantity of dust obtained throughout the experiment¹. Coarse particles (sand, pieces of wood, fibers of 5 mm or longer etc.) were removed with forceps. On the average the fine fraction (mainly human skin scales and small fibers) weighted 85% of the total dust sample and was used for arthropod and fungal analysis².

The dust fauna of each mattress was analyzed in 3–4 replicates of 0.025 g dust with a flotation method (Bronswijk et al., 1978). Before mounting in Hoyer's the active mites were separated from inactive (dead or quiescent) specimens.

To isolate xerophilic fungi, 3–4 replicates of 0.02 g fine dust from each mattress were surface inoculated onto malt extract agar (Oxoid) with 64% sucrose (MEA 64) using a dilution plate count method (Bronswijk et al., 1978). Colonies were counted on 3 agar plates at dilutions of 10^0 or 10^{-1} and the numbers found were expressed as the number of diaspores/0.006 g dust.

¹ However, after a period without nocturnal occupations (Juli 1–Juli 29 1977, during summer holidays) the mattresses yielded less dust than after a period with a maximal number of occupations (November 19–December 17 1976; $0.01 < P < 0.05$)

² From one mattress (no. 2) I obtained more dust (and fine dust) than from the others throughout the experiment ($P < 0.01$)

Colonies with an aberrant texture were transferred to appropriate media for further identification (Raper and Fennell, 1965; Raper and Thom, 1949; Smith, 1971). Air-borne fungi were collected on each sampling date by exposing 3 MEA-64 agar plates to the room air of the cottage for 20 min. Three replicates were taken. The experiment was also repeated with uninoculated media in order to detect contamination. Non-sporulating mycelia could not be identified and were excluded from Results. From October 1976 to October 1977, the non-sporulating mycelia comprised 8% of the dust isolates and 12% of the air-borne isolates.

The Friedman Test based on mean ranks was applied for testing the null hypothesis that the number of pyroglyphid mites or the number of fungi in dust is independent of the mattress from which the sample was taken or independent of the date of observation. The significance of pairwise differences between mattresses and dates of observation with respect to the amount of dust, the number of pyroglyphid mites and the number of fungi was determined with the Multiple Comparison Test of Nemenyi-Friedman (Miller, 1966). Spearman correlations (Siegel, 1956) were computed to compare the seasonal trends of some variables. During a 1-year cycle, from October 1976 to October 1977, the following variables were compared: outdoor temperature in °C, outdoor relative humidity in %, outdoor absolute humidity in g/m³ (means of 4 weeks), number of pyroglyphid mites, number of fungi in dust (means of 3–4 replicates of 5 mattresses) and the number of air-borne fungi (means of 3 replicates).

Results

From October 1976 to October 1977 the arthropod fauna of mattress dust consisted mainly of Pyroglyphidae (97%). These mites were represented by *Dermatophagoides pteronyssinus* (Trouessart 1897) (58%) and *Euroglyphus maynei* (Cooreman 1950) (30%). Ten percent of the pyroglyphid mites were eggs or material which had been strongly damaged and could not be definitely determined. A minority of the arthropod fauna (3%) consisted of non-pyroglyphid mites as *Demodex* sp., Cheyletidae, Tarsonemida, Oribatida and Eriophyidae.

All the active mites belonged to the species *D. pteronyssinus* and *E. maynei*. Larvae were the most abundant (49%), but active protonymphs (18%), tritonymphs (10%), females (17%) and males (6%) were also observed. But most of the pyroglyphid specimens were inactive (86%).

Table 1. Mean ranks of 5 mattresses (numbered 1 to 5) and their differences with respect to the numbers of pyroglyphid mites and fungi in dust^a

Organism	Rank per mattress number					Difference between total number of ranks ^b	Pairwise difference between ranks ^c
	1	2	3	4	5		
Inactive mites	2.08	2.89	3.81	2.65	3.58	+	(3,1)*
Active mites	3.06	2.75	4.19	2.88	2.13	+	(3,5)*
<i>A. restrictus</i> group	3.54	2.38	2.77	2.65	3.65	—	—
<i>A. glaucus</i> group	3.65	2.81	3.38	3.00	2.15	—	—
<i>W. sebi</i>	2.85	2.81	3.27	2.69	3.38	—	—
<i>Penicillium</i> spp.	2.42	4.58	3.15	2.12	2.73	++	(2,4)**, (2,1)**, (2,5)*

* $0.01 < P < 0.05$; ** $P < 0.01$

^a Computed from 13 observations within the period of October 1976 to October 1977

^b Friedman Test

^c Multiple Comparison Test of Nemenyi-Friedman

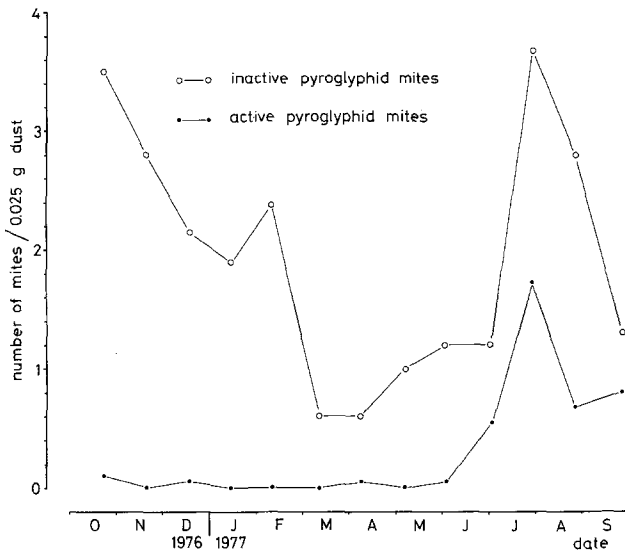


Fig. 1. Average numbers of pyroglyphid mites in dust of 5 mattresses

Table 2. Mean ranks of 13 sampling dates and their differences with respect to the numbers of

Organism	Rank per date									
	Oct 22 1976	Nov 19 1976	Dec 17 1976	Jan 14 1977	Feb 11 1977	Mar 11 1977	Apr 8 1977	May 8 1977	Jun 3 1977	
Inactive mites	10.0	9.7	8.6	8.0	8.4	2.5	2.6	5.4	5.6	
Active mites	6.8	4.9	5.8	4.9	4.9	4.9	5.8	4.9	5.8	
<i>A. restrictus</i> group	9.8	6.3	6.6	4.1	5.2	3.6	4.0	4.1	3.8	
<i>A. glaucus</i> group	3.9	9.7	4.5	5.7	5.2	2.3	9.6	7.6	5.0	
<i>W. sebi</i>	12.2	7.6	9.7	6.0	6.5	5.5	5.4	5.1	5.2	
<i>Penicillium</i> spp.	8.0	3.9	3.9	3.9	6.6	2.3	3.6	9.7	10.1	

* $0.01 < P < 0.05$; ** $P < 0.01$

^a Computed from 5 mattresses

^b Friedman Test

^c Multiple Comparison Test of Nemenyi-Friedman

The fungi isolated from mattress dust most frequently belonged to the *Aspergillus restrictus* group (48%). Other taxa included *Penicillium* spp. (25%), fungi of the *A. glaucus* group (16%), *Wallemia sebi* (Fr.) v. Arx (3%) and *A. versicolor* (Vuill.) Tirab. (1%). The 195 isolates of the *A. restrictus* group which were identified to species level belonged all to *A. penicilloides* Speg. The 21 *Penicillium* isolates were divided into 14 isolates of *P. brevicompactum* Diercks and 7 ones of *P. chrysogenum* Thom. *A. glaucus* was mainly represented by *Eurotium repens* Corda (12 of 14 isolates). Both *E. amstelodami* Mangin and *E. halophilicum* Christensen et al. were isolated once. The same taxa were present among the air-borne fungi. But *A. restrictus* (30%), *Penicillium* spp. (27%) and *W. sebi* (21%) occurred more frequently than *A. glaucus* (7%) and *A. versicolor* (3%).

From October 1976 to October 1977 mattress no. 3 contained the highest numbers of pyroglyphid mites. During this period it was located in a separate room. The differences between this mattress and the numbers 1 and 5 were significant (Table 1). The numbers of inactive pyroglyphid mites encountered decreased slowly in the course of the experiment. Every month of 1976 yielded more inactive mites than the corresponding one of 1977. Active pyroglyphid mites were absent in most dust samples of the winter period 1976/1977. After the central heating system was turned off in May, the indoor relative humidity rose following the seasonal changes outdoors. The outdoor temperature reached 14.5° C in June and 16.5° C in July and the outdoor relative humidity did not fall below 76% (Figs. 3 and 4). Under these conditions the numbers of

pyroglyphid mites and fungi in dust^a

Jul 1 1977	Jul 29 1977	Aug 26 1977	Sep 30 1977	Difference between total number of ranks ^b	Pairwise difference between ranks ^c
4.2	10.8	10.1	5.1	**	(Jul 29, Mar 11)*, (Jul 29, Apr 8)*
10.1	12.2	10.2	11.8	**	(Jul 29, Nov 19)*, (Sep 30, Nov 19)* (Jul 29, Jan 14)*, (Sep 30, Jan 14)* (Jul 29, Feb 11)*, (Sep 30, Feb 11)* (Jul 29, Mar 11)*, (Sep 30, Mar 11)* (Jul 29, May 6)*, (Sep 30, May 6)*
12.0	13.0	9.8	8.7	**	(Jul 29, Mar 11)***, (Jul 29, May 6)* (Jul 29, Jun 3)*, (Jul 1, Mar 11)* (Jul 29, Apr 8)*, (Jul 1, Jun 3)* (Jul 29, Jan 14)*
8.4	10.9	10.6	7.6	**	(Jul 29, Mar 11)*, (Aug 26, Mar 11)*
8.5	8.6	6.8	3.9	*	(Oct 22, Sep 30)*
12.2	7.1	10.6	9.1	**	(Jul 1, Mar 11)***, (Jul 1, Dec 17)* (Jul 1, Apr 8)*, (Jul 1, Jan 14)* (Jul 1, Nov 19)*, (Aug 26, Mar 11)*

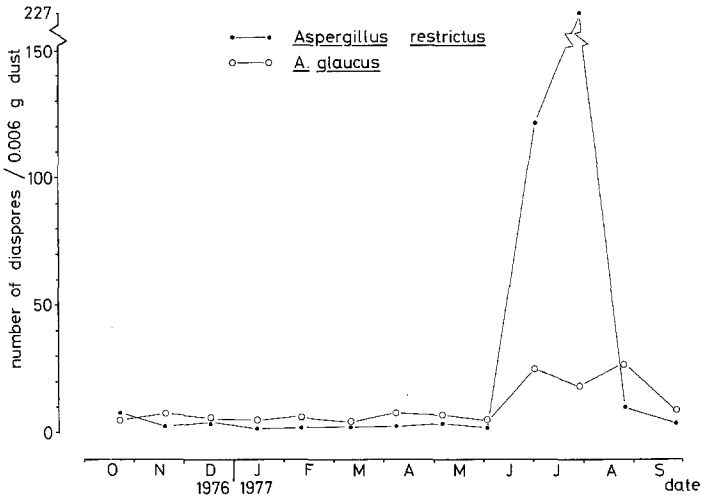


Fig. 2. Average numbers of xerophilic *Aspergillus* diaspores in dust of 5 mattresses

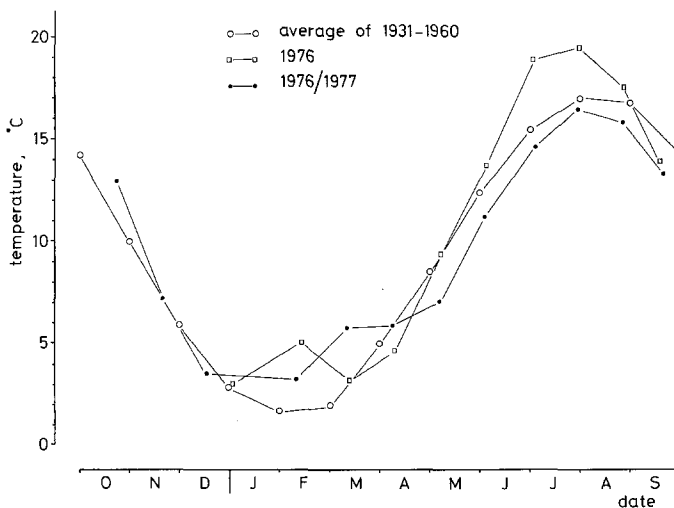


Fig. 3. Average outdoor temperature at 1.5 m above soil surface

active mites increased from June to a maximum of 69 specimens/g dust at the end of July (Fig. 1, Table 2). In the winter of 1976/1977 the numbers of dust fungi were also low and seldom surpassed 20 diaspores/0.006 g dust (or 3.3×10^3 diaspores/g dust). In June *Penicillium* spp. initiated a fungal increase and reached 7.2×10^3 diaspores/g dust on July 1 (Table 2). In agreement with the pyroglyphid mites, maximal numbers of fungi were obtained at the end of July. *A. restrictus* contributed the most to this peak (62–79% of the isolates, Table 3) with a maximum of 3.8×10^4 diaspores/g dust (Fig. 2). It is noteworthy

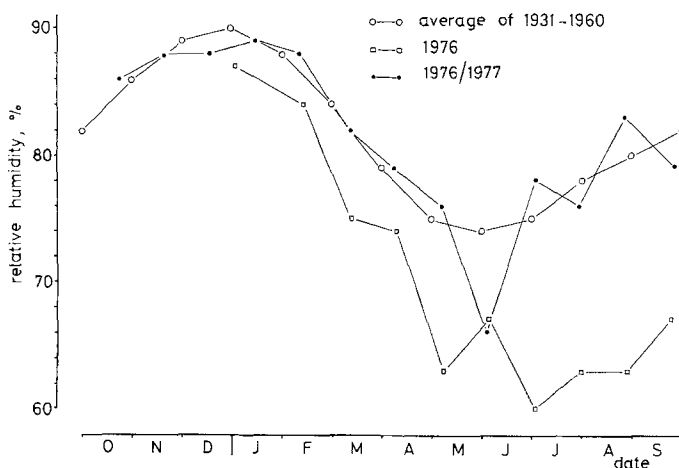


Fig. 4. Average outdoor relative humidity at 1.5 m above soil surface

Table 3. Species composition of the dust and air-borne fungal flora at periods of seasonal increase of fungi

Date of isolation	Fungi (% of total isolates) ^a				
	<i>Aspergillus restrictus</i>	<i>A. glaucus</i>	<i>Wallemia sebi</i>	<i>Penicillium</i> spp.	<i>A. versicolor</i>
Dust fungi:					
Jul 2 '76	0	0	0	98	—
Jul 30 '76	2	4	0	73	—
Jul 1 '77	62	13	1	21	1
Jul 29 '77	79	7	2	10	0
Air-borne fungi:					
Nov 19 '76	11	5	4	65	7
Dec 17 '76	42	5	44	2	1
Jan 14 '77	22	22	7	—	—
Feb 11 '77	26	4	2	46	—
Mar 11 '77	34	2	2	47	2

^a Non-sporulating mycelia are excluded

that this significant increase (Table 2) occurred within the summerholidays, which extended from June 17 to August 15, when the doors and windows of the cottage were closed. A smaller but distinct increase of *A. glaucus* was observed from July up to 4.7×10^3 diaspores/g dust in August (Fig. 2, Table 2). The numbers of *W. sebi* and *A. versicolor* did not surpass 0.5×10^3 and 0.3×10^3 diaspores/g dust, respectively.

Air-borne fungi were isolated more frequently during the winter (Fig. 5). A maximum of 83 diaspores on 3 agar plates/20 min exposure time occurred

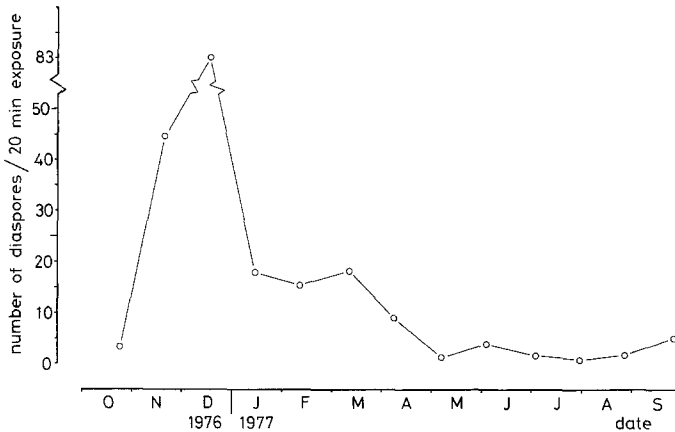


Fig. 5. Average numbers of air-borne fungi indoors on 3 MEA-64 plates/20 min exposure time

Table 4. Correlation between seasonal trends of pyroglyphid mites in mattress dust, fungi in mattress dust, air-borne fungi and outdoor climate (Spearman Rank Correlation Coefficients, r_s)^a

	Outdoor temperature	Outdoor relative humidity	Outdoor absolute humidity	Active mites	<i>Aspergillus restrictus</i>	<i>Penicillium</i> spp.
Active mites	0.84**	-0.42	0.81**			
<i>A. restrictus</i>	0.77**	-0.22	0.76**	0.74**		
<i>Penicillium</i> spp.	0.72*	-0.60*	0.70*	0.59*	0.54	
Air-borne fungi	-0.74**	-0.71*	0.73*	-0.57*	-0.66*	-0.77**

* $0.01 < P < 0.05$; ** $P < 0.01$

^a Computed from 13 observations within the period of October 1976 to October 1977

in December 1976. The species composition of the air flora changed every month (Table 3).

The corresponding seasonal trends of pyroglyphid mites and *A. restrictus* in mattress dust were correlated to the fluctuations of outdoor temperature and absolute humidity (Table 4). These climate fluctuations were also positively correlated to the number of *Penicillium* diaspores but negatively to the number of air-borne fungi.

The summer of 1976 was exceptionally hot and dry (Figs. 3 and 4). A premature decline of the pyroglyphid mite populations was observed on July 2 after 9 days with a mean maximum temperature of 31.1° C (range 27.5–33.6° C) and a mean minimum relative humidity of 25% (range 16–31%). In addition, the fungi, except for *Penicillium* spp., did not show a seasonal increase in July. *Penicillium* spp. reached a maximum of 3.4×10^5 diaspores/g dust which is 47 times higher than the maximum of 1977. In contrary to 1977, the cottage was in use during the summer holidays. In July 1976 73–98% of the fungal isolates belonged to *Penicillium* (Table 3). Most of the *Penicillium* isolates origi-

nated from the mattresses no. 2 and 3 which were located in the same room until September 1976. From September 1976 mattress no. 2 was located in a separate room and continuously yielded most *Penicillium*. The differences with mattresses no. 1, 4 and 5 were significant (Table 1). No such difference was observed for *A. restrictus*, *A. glaucus* or *W. sebi*.

Discussion

Numerous dust particles (skin scales, textile fibers, pollen, fungal and algal diaspores, food crumbs etc.) accumulate on floors and furniture of our houses and offer a rich diet to saprophytic organisms. Mattresses, upholstered chairs, floor crevices etc. provide plenty of hiding-places and are well-suited as a habitat for small arthropods. However the prevailing humidities are low and limiting for arthropod development, especially in central heated rooms (Bronswijk, 1973; Dusbábek, 1975). Pyroglyphid mites are well-adapted to live under dry conditions and can colonize house dust in summertime. However in the tropics, the cool (and wet) season is more favourable for mite development (Sharp and Haramoto, 1970; Dar, 1976).

The development of pyroglyphid mite populations may be retarded by saprophytic house-inhabiting species. Sharp and Haramoto (1970) reported a possible competition between pyroglyphid mites and *Tyrophagus putrescentiae*, *Glycyphagus domesticus* and *Suidasia medanensis* in floor dust.

The incidence of Cheyletidae in our dust samples was low and did not suggest that these predator mites effectively controlled the pyroglyphid mite populations. The hair-follicle mite, *Demodex* sp., which can obviously penetrate into beds, was also found. *Demodex* can be a major part of the mattress-dust fauna (Lustgraaf and Jorde, 1977). It is not known whether *Demodex* can develop in house dust and reinfect humans and pets.

The abundance of hydro- and mesophilic fungi in house dust seems not to be affected by seasonal changes (Voorhorst et al., 1969). Xerophilic fungi are probably the most essential organisms regarding the survival of pyroglyphid mites in house dust. These fungi, especially *A. penicilloides*, showed a seasonal maximum in July, even though the cottage was closed and penetration from the outside was negligible. Conidia of *A. penicilloides*, *E. repens* and *W. sebi* may germinate and form a mycelium on human dander in the indoor summer climate (Lustgraaf et al., 1978). Xerophilic fungi may, in fact, be able to develop in the modern dry houses of a temperate climate by colonizing house dust. The ratio of pyroglyphid mites/*A. penicilloides* at the corresponding seasonal peak, i.e. 1/500, agrees with the ratio found in a laboratory experiment, which demonstrated the beneficial effect of fungal growth to the mites in mattress dust. Probably the beneficial effect includes a predigesting of human dander fats by the fungi (Lustgraaf, 1978). It can be concluded, that xerophilic fungi can be synergistic to the pyroglyphid mites in house-dust environment.

The concentration at which *A. penicilloides* was harmful to *D. pteronyssinus* (Lustgraaf, 1978) was approximately 4.5×10^3 times as high as the concentration in which this fungus was isolated from mattress dust. It is unlikely that

fungi in modern houses of Western Europe can reach numbers high enough to be antagonistic to pyroglyphid mites.

The numbers of air-borne fungi did not reflect the seasonality of fungi in mattress dust. Probably the fungal spores are more easily released from the dry dust of central heated rooms (Burnett, 1976) and therefore were collected more frequently in wintertime. These results do not agree with those of Solomon (1975) who isolated 30% less diaspores of *Aspergillus* and *Penicillium* from indoor air in wintertime.

In July of both 1971 (Bronswijk, 1973) and 1977 pyroglyphid mite populations reached a maximum density in mattresses of The Netherlands. However during the extremely dry and hot summer of 1976 (KNMI, 1976) we found hardly any living mite in July, and no increase of *A. restrictus* diaspores. Domrov (1970) found that the number of house-dust mites drops after 6 hot days. Obviously a dry and hot summer is unsuitable for studying the normal seasonal incidence of house-dust inhabiting organisms.

To isolate the true dust-inhabiting fungi we used malt extract agar with 64% sucrose. On this medium *Penicillium* was the most abundant form in July 1976, although this fungus probably can not develop a mycelium in mattress environment (Lustgraaf et al., 1978). *Penicillium* was most abundantly isolated from the 2 mattresses which were located in a room with many window plants. Possibly *Penicillium* diaspores penetrated the beds from mycelia present in the humid potsoil. These fungi, originating from a different niche, may have suppressed the growth of the true house-dust inhabiting fungi on the isolation plates. To eliminate such opportunistic fungi, different agar media with a low content of water could be used.

As their diaspores are easily released into the indoor air, xerophilic fungi are better equipped to colonize fresh dust than pyroglyphid mites. This may explain why xerophilic fungi were isolated in equal proportions from the mattresses while one of the mattresses contained a denser population of mites than the others.

Acknowledgements. The author is much indebted to Prof. Dr. H.F. Linskens for his stimulating supervision, to Drs. Ph. van Elteren and Ir. H.J.J. van Lier for their statistical advice, to Mr. A. van de Lustgraaf for preparing the graphs and to Mrs. Ann Jenks-Couplan for correcting the manuscript.

References

- Bronswijk, J.E.M.H.v.: *Dermatophagoides pteronyssinus* (Trouessart 1897) in mattress and floor dust in a temperate climate (Acari:Pyroglyphidae). J. Med. Entomol. **10**, 63–70 (1973)
- Bronswijk, J.E.M.H.v.: Hausstaubmilben: Vorkommen und Bedeutung. Allergologie **1**, 55–60 (1978)
- Bronswijk, J.E.M.H.v., Sinha, R.N.: Role of fungi in the survival of *Dermatophagoides* (Acarina:Pyroglyphidae) in house-dust environment. Environm. Entomol. **2**, 142–145 (1973)
- Bronswijk, J.E.M.H.v., Saint Georges-Grèdelet, D. de, Lustgraaf, B.v.d.: An evaluation of biological methods in house-dust allergen research. Allergie u. Immunol. **24**, 24–28 (1978)
- Burnett, J.H.: Fundamentals of mycology, pp. 673, 2nd ed. London: Arnold 1976
- Dar, N.: The role of house-dust mites in causation of bronchial asthma and allergic rhinitis in India. PhD thesis, Univ. of Delhi, pp. 211 (1976)

- Domrov, R.: Seasonal variation in numbers of the house-dust mite in Brisbane. *Med. J. Australia* **2**, 1248–1250 (1970)
- Dusbábek, F.: Population structure and dynamics of the house-dust mite *Dermatophagoides farinae* (Acarina:Pyroglyphidae) in Czechoslovakia. *Folia Parasitologica (Praha)* **22**, 219–231 (1975)
- Furumizo, R.T.: The biology and ecology of the house-dust mite *Dermatophagoides farinae* Hughes, 1961 (Acarina:Pyroglyphidae). PhD thesis, Univ. of California, Riverside, pp. 153 (1973)
- Hughes, A.M., Maunsell, K.: A study of a population of house dust mite in its natural environment. *Clin. Allergy* **3**, 127–131 (1973)
- Koninklijk Nederlands Meteorologisch Instituut (KNMI): De droogte van 1976, pp. 33, Publikatie 154. De Bilt: KNMI 1976
- Lustgraaf, B.v.d.: Xerophilic fungi in mattress dust. *Mykosen* **20**, 101–106 (1977)
- Lustgraaf, B.v.d.: Ecological relationships between xerophilic fungi and house-dust mites (Acarida: Pyroglyphidae). *Oecologia (Berl.)* **33**, 351–359 (1978)
- Lustgraaf, B.v.d., Bronswijk, J.E.M.H.v.: Fungi living in house-dust. *Ann. Allergy* **39**, 152 (1977)
- Lustgraaf, B.v.d., Jorde, W.: Pyroglyphid mites, xerophilic fungi and allergenic activity in dust from hospital mattresses. *Acta Allergol.* **32**, 406–412 (1977)
- Lustgraaf, B.v.d., Rijckaert, G., Linskens, H.F.: Ökologie der Hausstaub-Allergene. *Allergologie* **1**, 61–73 (1978)
- Miller, R.G.Jr.: Simultaneous statistical inference, pp. 272. New York: McGraw Hill 1966
- Miyamoto, J., Ouchi, T.: Ecological studies of house-dust mites. Seasonal changes in mite populations in house dust in Japan. *Jap. J. Sanitary Zool.* **27**, 251–259 (1976)
- Mumcuoglu, Y.: Zur Biologie der Hausstaubmilbe *Dermatophagoides pteronyssinus*. II. Milbenhäufigkeit in den verschiedenen Regionen der Schweiz und ihre Abhängigkeit vom Klima. *Schweiz. Med. Wschr.* **105**, 1013–1020 (1975)
- Oshima, S.: Seasonal prevalence of house-dust mites and its causative factors. *Surg. Int. Med. Ped.* **7**, 461–468 (1975)
- Popescu, I.G., Bănescu, O.: Presence of *Dermatophagoides pteronyssinus* in the houses of asthmatics sensitized to house dust. A one year study. *Rev. Roum. Méd.-Méd. Int.* **13**, 293–295 (1975)
- Raper, K.B., Fennell, D.I.: The genus *Aspergillus*, pp. 686. Baltimore: Williams & Wilkins 1965
- Raper, K.B., Thom, C.: A manual of the penicillia, pp. 875. Baltimore: Williams & Wilkins 1949
- Shamiyeh, N.B., Bennett, S.E., Woodiel, N.L., Hornsby, R.P.: Distribution of house-dust mites in Knoxville and Oak Ridge, Tennessee. *Tennessee Farm and Home Sci.* **83**, 34–36 (1972)
- Sharp, J.L., Haramoto, F.H.: *Dermatophagoides pteronyssinus* (Trouessart) and other Acarina in house dust in Hawaii. *Proc. Hawaiian Entomol. Soc.* **20**, 583–589 (1970)
- Siegel, S.: Nonparametric statistics for the behavioral sciences, pp. 312. Tokyo: McGraw-Hill Kogakusha 1956
- Smith, G.: An introduction to industrial mycology, pp. 390. London: Arnold 1971
- Solomon, W.R.: Assessing fungus prevalence in domestic interiors. *J. Allergy Clin. Immunol.* **56**, 235–242 (1975)
- Voorhorst, R., Spijksma, F.Th.M., Varekamp, H.: House-dust atopy and the house-dust mite, pp. 159. Leiden: Stafleu 1969
- Wharton, G.W.: House-dust mites. *J. Med. Entomol.* **12**, 577–621 (1976)

Received April 27, 1978