

House-Dust Community (Fungi, Mites) in Different Climatic Regions *

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Summary. House-dust flora and fauna were compared in the maritime cool temperate climate (in three degrees of continentality), the mediterranean warm temperate climate, the arctic climate and the tropical climate.

An inverse relationship exists between continentality of the temperate climate and the numbers of arthropods and fungi (mesophilic as well as xerophilic) in the dust of the houses.

The numbers of arthropods and fungi were lowest in mediterranean and arctic climates, most likely because of the limiting effect of the drier indoor climate. Fungi are more tolerant of dry conditions than house-dust inhabiting mites. Generally the highest numbers of fungal diaspores and arthropods were found in the tropics, where, however, the lowest number of positive samples was also found, especially for the species of the *Aspergillus glaucus* group and for *Wallemia sebi*. Maritime cool temperate climate showed the highest numbers of positive samples for fungi and mites.

In general, a relationship exists between relative humidity and the density of fungal diaspores and arthropods.

Introduction

The concept of a house-dust ecosystem was first developed by Bronswijk (1972) to describe and cover that community present in the dust of Western European houses. The dominant organisms in this ecosystem are pyroglyphid mites and xerophilic fungi (Lustgraaf 1978; Spieksma 1967).

Houses in the cool temperate climate are obviously a borderline habitat so far as humidity is concerned, especially for pyroglyphid mites (Bronswijk in press; Lustgraaf 1978). A drier indoor climate is to be expected in very cold climates (such as that of the arctic) and in fairly dry climates (such as the dry variants of the mediterranean climate). In houses in these climatic regions, pyroglyphid mites are expected to be almost absent. On the other hand, in the wet tropical climates, mites could have a better chance of flourishing as compared to the cool temperate climate, unless they are beaten out competitively by other house-dust inhabiting arthropods. The same pattern can be expected for the xerophilic fungi.

In a cool temperate climate, winter becomes colder and the indoor climate drier the more continental the climate is. Theoretically, an inverse relationship is to be expected between continentality

and numbers of mites and fungal diaspores present in house dust.

Thanks to the cooperation of scientists visiting countries in different continents we were able to compare the mite fauna and fungal flora in the dust from different types of climates, in order to test the above mentioned hypotheses.

Material and Methods

Samples were collected from localities in the following climatic regions [classification and description according to Bucknell (1967)]:

– Maritime cool temperate climate (C_1): 1–5 months below 6.1°C ; rain in all seasons, with a possible maximum in winter. Three degrees of continentality: Amsterdam (NL): 5 samples; Nijmegen (NL): 5 samples and Mönchengladbach (FRG): 5 samples; all samples were collected in July 1979.

– Mediterranean warm temperate climate (B_1): all months above 6.1°C but some below 17.8°C ; rain in winter. Samples were collected from: Ankara, Nevsehir, Konya, Bursa and Izmir (Turkey) in July 1978 and from Mardin, Kahta, Altinbasak and Istanbul (Turkey) in April 1979.

– Maritime tropical climate (A_2): no month below 17.8°C ; no dry season. Samples were collected from: Botucatu, Valinhos and São Paulo (Brazil) in January 1978 and from Nampala, Raselma and Lere (Mali) in September 1979.

– Continental tropical climate (A_3): no month below 17.8°C ; rain in summer. Samples were collected from: Manaus (Brazil) in January 1978 and from Bamako (Mali) in October 1979.

– Arctic climate (E): less than 3 months above 6.1°C . Two samples were collected from Holsteinsborg (Greenland) in March 1978. Fungi could only be isolated from the larger sample.

Unfortunately it was not possible to collect all the samples at the height of the mite and fungal season. Therefore, it was only possible to detect very large differences among the house-dust communities in the different climatic regions. However, the comparisons within the maritime cool temperate climate were more subtle since here it was possible to collect all samples in the same month. July is one of the known peak months in temperate climates (Bronswijk in press; Lustgraaf 1978).

Most of the house-dust samples were taken by means of a vacuum cleaner. In Mali, parts of the upper layer of the sandy floor were collected with a scoop. With both methods, only part of the fauna is sampled and the large house-dust inhabiting species are missed. In addition, the method used in Mali tends to lower the diversity found in the samples.

For the arthropodal analysis $2 \times 0.5\text{ g}$ dust was examined by means of the flotation method of Bronswijk (in press). The number of fungal diaspores was determined by means of the dilution plate method of Lustgraaf (1978). In all cases but one 0.02 g fine dust was used for the analysis. Only 0.015 g fine dust was used in the sample of Kahta (Turkey) because of the small amount of dust collected. The samples

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Table 1. Median and range of fungal spores per species and arthropods per group per g dust of the positive samples (i.e. those samples in which the given organism(s) is(are) present), total number of samples (*n*) and percentage of positive samples (%) from different climates

Organism(s)	Median, range and percentage (%) of positive samples in								
	maritime temperate climate (<i>n</i> =15)			mediterranean climate (<i>n</i> =9)			tropical climates (<i>n</i> =8)		
	median	range	%	median	range	%	median	range	%
<i>Aspergillus amstelodami</i>			0			0	1.1 × 10 ³	(0.5– 1.7) 10 ³	25
<i>A. chevalieri</i>	0.5 × 10 ³	(0.2– 46.7) 10 ³	80	0.7 × 10 ³	(0.3– 2.9) 10 ³	56	0.7 × 10 ³	(0.2– 625.0) 10 ³	38
<i>A. repens</i>	3.8 × 10 ³	(0.9– 302.0) 10 ³	100	0.8 × 10 ³	(0.1–12.7) 10 ³	100	2.3 × 10 ³	(1.8– 50.0) 10 ³	63
<i>A. ruber</i>	2.9 × 10 ³	(0.8– 85.3) 10 ³	87	1.1 × 10 ³	(0.1– 5.5) 10 ³	67	497.5 × 10 ³	(61.7– 933.3) 10 ³	25
<i>A. penicilloides</i>	6.5 × 10 ³	(0.1– 304.0) 10 ³	93	0.4 × 10 ³	(0.1– 1.3) 10 ³	67	43.3 × 10 ³	(3.3–1,016.6) 10 ³	38
<i>A. restrictus</i>	2.6 × 10 ³	(0.1– 266.7) 10 ³	93	0.4 × 10 ³	(0.1– 0.8) 10 ³	44	735.6 × 10 ³	(44.4–1,483.4) 10 ³	50
<i>A. versicolor</i>			0	0.8 × 10 ³	(0.1– 1.7) 10 ³	67			0
<i>Wallemia sebi</i>	8.2 × 10 ³	(0.1–1,743.9) 10 ³	93	0.4 × 10 ³	(0.1–15.5) 10 ³	78	816.7 × 10 ³	(6.7–1,366.7) 10 ³	50
<i>Penicillium spec.</i>	1.0 × 10 ³	(0.1– 2.0) 10 ³	13	2.5 × 10 ³	(0.4–14.5) 10 ³	44	113.9 × 10 ³	(1.1– 566.7) 10 ³	50
Pyroglyphidae	8.0	1.0– 182.0	67	1.0	1.0– 1.0	11	100.0	15.0– 123.0	38
predator mites	2.5	1.0– 11.0	40			0	68.0	3.0– 200.0	50
other mites	2.0	1.0– 11.0	67	18.0	1.0–21.0	33	10.0	2.0– 500.0	63
insects	1.0	1.0– 3.0	40	3.0	1.0– 5.0	22			0

from the maritime cool temperate climate and the mediterranean warm temperate climate were 8 and 64 times diluted; the other samples 10 and 100 times.

For the comparison of the results of the fungal analysis of the dust from the different climates, the test of Kruskal-Wallis ($\alpha=5\%$) was used considering only those samples in which a given species is present. If this test was significant ($p<0.05$) the difference among the climates was specified by applying Wilcoxon's two sample test ($\alpha=5\%$) on each pair of climates.

Results and Discussion

Qualitative and quantitative differences seem to exist between the house-dust communities in the different climatic regions. *Aspergillus amstelodami* (Table 1) was only found in the tropical climates. However, on other occasions, this species has been observed in house dust in Germany and The Netherlands (Bronswijk, in press). *A. chevalieri*, *A. ruber* and *Wallemia sebi* (Table 1) were isolated in all climatic regions except the arctic one. *A. chevalieri* and *A. ruber* were found previously in bed dust from The Netherlands only (Bronswijk, in press); *Wallemia* species in house dust from Yugoslavia, The Netherlands and Japan (Bronswijk, in press; Ishii et al. 1979). *A. repens*, *A. penicilloides* and *A. restrictus* (Table 1) were present in all climatic regions. *A. repens* has previously been isolated from house dust in England, France and The Netherlands (Bronswijk, in press); *A. penicilloides* from floor and bed dust in The Netherlands only (Bronswijk, in press) and *A. restrictus* from bed dust in France and The Netherlands (Bronswijk, in press). *A. versicolor* (Table 1) was found in house dust from the mediterranean climate only. Previously it has been reported in house dust in Canada, England, France, Germany, The Netherlands and Japan (Bronswijk, in press; Ishii et al. 1979). Pyroglyphid mites were absent in the arctic climate and almost absent in the mediterranean one (Table 1). It is an established fact that while these mites are presently abundant in the temperate and tropical climates they were previously also found in the mediterranean region (Bronswijk, in press). As to the insects, a low number of dust lice (Corrodentia) was observed in most climatic regions. Silverfishes and cockroaches were not found. However, the absence

of these insects and the low number of dust lice is most likely caused, in part, by the sampling procedures.

As can be seen in Tables 1 and 2, the quantitative differences between the different climatic regions are difficult to study because of the enormous variation within the climates.

The numbers of organisms found in Holsteinsborg were not incorporated in the statistical analysis since the number of samples (two for arthropodal analysis and one for fungal analysis) was too small. In addition to the absence of mites, the "inhabitability" of the dust is also shown by the low numbers of fungi found, i.e. 1,000 diaspores of *A. repens* per g dust, 1,100 diaspores of *A. restrictus* per g dust, 110 diaspores of *A. penicilloides* per g dust and 2,000 diaspores of *Penicillium* sp. per g dust (compare these figures with those found in the other climatic regions in Table 1). Because of the severe outdoor situation, Holsteinsborg is expected to have the driest indoor climate of the climatic regions studied.

The mediterranean warm temperate climate will also have a fairly dry indoor climate because of the warm and dry period that occurs from June to October. Fungal numbers seem to be higher here than in Holsteinsborg. Statistically significant differences were established between the mediterranean climate and the maritime cool temperate climate as far as *A. repens* ($p_{\text{Wilcoxon}}=0.02$), *A. ruber* ($p_{\text{Wilcoxon}}=0.04$) and *A. penicilloides* ($p_{\text{Wilcoxon}}=0.01$) are concerned; statistically significant differing from the tropical climates were the numbers of *A. penicilloides* ($p_{\text{Wilcoxon}}=0.02$), *A. restrictus* ($p_{\text{Wilcoxon}}=0.02$) and *W. sebi* ($p_{\text{Wilcoxon}}=0.02$).

The highest numbers of mites and fungi are found in the tropical climates (Table 1). The widest ranges in the numbers per g dust are also seen in these climates. Clearly, the relative humidity indoors cannot be a limiting factor in the tropics as long as air-conditioning is not used. Outdoors, almost all year round the monthly precipitation exceeds 100 mm. This is a good explanation for the higher numbers found in the tropics, but not for the extreme ranges. The important limiting factors in these regions could be interspecific competition within the house-dust community and influences from outdoor organisms entering the house. Tropical housing is usually more open, facilitating

Table 2. Median and range of fungal spores per species and arthropods per group per g dust of the positive samples (i.e. those samples in which the given organism(s) is(are) present), total number of samples (*n*) and percentage of positive samples (%) from 3 localities in the maritime cool temperate climate

Organism(s)	Median, range and percentage (%) of positive samples in								
	Amsterdam (<i>n</i> =5)			Nijmegen (<i>n</i> =5)			Mönchengladbach (<i>n</i> =5)		
	median	range	%	median	range	%	median	range	%
<i>Aspergillus chevalieri</i>	22.0 × 10 ³	(0.7– 46.7) 10 ³	80	0.5 × 10 ³	(0.3–13.3) 10 ³	80	0.3 × 10 ³	(0.2– 0.3) 10 ³	80
<i>A. repens</i>	10.0 × 10 ³	(3.3– 302.0) 10 ³	100	3.8 × 10 ³	(2.5–29.2) 10 ³	100	1.5 × 10 ³	(0.9– 7.3) 10 ³	100
<i>A. ruber</i>	8.9 × 10 ³	(2.0– 85.3) 10 ³	100	3.8 × 10 ³	(1.8–14.7) 10 ³	80	1.8 × 10 ³	(0.8– 2.9) 10 ³	80
<i>A. penicilloides</i>	225.3 × 10 ³	(124.0– 309.3) 10 ³	80	5.2 × 10 ³	(3.1–10.5) 10 ³	100	3.1 × 10 ³	(0.1–18.8) 10 ³	100
<i>A. restrictus</i>	107.3 × 10 ³	(12.0– 266.7) 10 ³	80	2.5 × 10 ³	(0.1– 2.9) 10 ³	100	0.2 × 10 ³	(0.1– 6.9) 10 ³	100
<i>Wallemia sebi</i>	72.3 × 10 ³	(22.0–1,743.9) 10 ³	80	3.8 × 10 ³	(0.5–26.8) 10 ³	100	0.7 × 10 ³	(0.1–15.6) 10 ³	100
Pyroglyphidae	75.5	29.0– 182.0	80	4.0	1.0–11.0	80	1.0	1.0– 1.0	40
Predator mites	4.5	1.0– 11.0	80			0	1.0	1.0– 1.0	20
Other mites	4.0	2.0– 11.0	100	2.0	1.0– 5.0	60	1.5	1.0– 2.0	40
Insects	1.0	1.0– 1.0	60	1.0	1.0– 3.0	60			0

the import of outdoor organisms. Statistically significant differences between the tropical and the mediterranean climates include some fungal species (see above); between tropical and maritime cool temperate climates *A. restrictus* ($p_{\text{Wilcoxon}}=0.03$).

The median numbers of organisms seen in house dust from the maritime cool temperate climate lay generally inbetween those from the tropical and the mediterranean climates (Table 1). Statistically significant differences from the mediterranean and the tropical climates concern some fungal species (see above). In the maritime cool temperate climate the precipitation in all seasons and the outdoor relative humidity of 70 to 80% in summer will cause a comfortable indoor climate, at least in summer. In winter, heating will cause a drop in relative humidity. In case the indoor relative humidity is really limiting, it is to be expected that continentality will be related to the numbers of organisms found (Table 2). In general, the most continental town, Mönchengladbach, has the lowest numbers of mites and fungi, while the most maritime town, Amsterdam, shows the highest numbers of these organisms. Statistically significant differences between Amsterdam and Nijmegen include the abundance of *A. penicilloides* ($p_{\text{Wilcoxon}}=0.02$), *A. restrictus* ($p_{\text{Wilcoxon}}=0.02$) and *W. sebi* ($p_{\text{Wilcoxon}}=0.03$). Amsterdam and Mönchengladbach differ significantly in the abundance of *A. chevalieri* ($p_{\text{Wilcoxon}}=0.03$), *A. penicilloides* ($p_{\text{Wilcoxon}}=0.02$), *A. restrictus* ($p_{\text{Wilcoxon}}=0.02$) and *W. sebi* ($p_{\text{Wilcoxon}}=0.02$).

Conclusion

The qualitative differences between the inhabitants of the house dust in the different climatic regions are slight. Pyroglyphid mites may be absent in very cold and very dry climates. As far as the fungi are concerned, at least three *Aspergillus* species (*A. penicilloides*, *A. repens* and *A. restrictus*) are cosmopolitan. The

abundance, however, of these cosmopolitan species is very much influenced by the outdoor climate. The highest numbers are found in the tropics; the lowest numbers in the dry mediterranean climate and in the arctic climate. The maritime cool temperate climate holds a middle position. Within this climatic region continentality tends to decrease the numbers of organisms present in house dust.

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